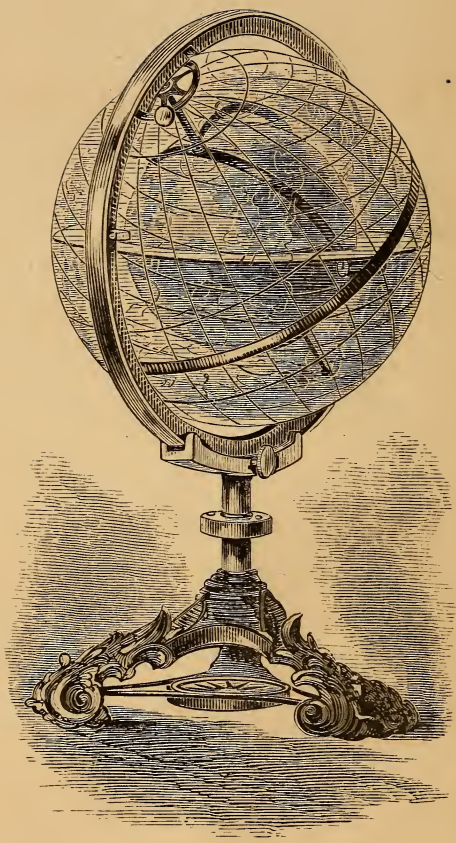
QB
66
.W7

LIBRARY OF CONGRESS.

Chap. Q366
Shelf .W7
Copyright No.

UNITED STATES OF AMERICA.



A MANUAL

OF

PROBLEMS ON THE GLOBES.

DESIGNED AS AN ACCOMPANIMENT TO

WILLIAMSON'S PATENT CONCENTRIC CELESTIAL AND TERRESTRIAL GLOBES.

BY

H. WILLIAMSON, M.D.,

PRINCIPAL OF GRAMMAR SCHOOL NO. 53, NEW YORK; INSTRUCTOR IN NATURAL PHILOSOPHY, ASTRONOMY, AND CHEMISTRY IN THE FEMALE NORMAL SCHOOL AND EVENING HIGH SCHOOL, NEW YORK.

1963 WASHINGTON

NEW YORK:
HARPER & BROTHERS, PUBLISHERS,
FRANKLIN SQUARE.
1868.

Entered, according to Act of Congress, in the year 1868, by

HARPER & BROTHERS,

In the Clerk's Office of the District Court of the United States for the Southern District of New York.

QP366
.W7

PREFACE.

The Author of the present little work, anticipating some difficulties in applying to his Concentric Celestial and Terrestrial Globes the rules for the solution of problems as laid down for ordinary globes in most works on Astronomy, felt the necessity of compiling a text-book of problems to accompany his globes by modifying and arranging to his purposes what has been so lucidly written by others.

He therefore respectfully presents to the public this little "Manual of Problems on the Globes," and hopes that while he has made it suitable to his own especially, he has rendered it applicable to other globes now in use.

New York, March, 1868.

CONTENTS.

CHAPTER I.

PAGE

GEOGRAPHICAL AND ASTRONOMICAL DEFINITIONS, WITH EXPLANATIONS 9

CHAPTER II.

PROBLEMS ON THE TERRESTRIAL GLOBE 20

CHAPTER III.

PROBLEMS TO BE PERFORMED WITH THE TERRESTRIAL AND CELESTIAL GLOBES 43

CHAPTER IV.

A CATALOGUE OF THE CONSTELLATIONS AND VISIBLE STARS, WITH THEIR LOCATIONS, REPRESENTATIONS, ETC. 54

CHAPTER V.

PROBLEMS TO BE PERFORMED BY MEANS OF THE CELESTIAL GLOBE 75

PROBLEMS ON THE GLOBES.

CHAPTER I.

GEOGRAPHICAL AND ASTRONOMICAL DEFINITIONS, WITH EXPLANATIONS.

An artificial Globe is a miniature representation of the earth or heavens; that which represents the earth is called the Terrestrial Globe, and that which represents the heavens the Celestial Globe.

On the surface of the terrestrial globe, the various natural and political divisions of the earth are laid down; and on the surface of the celestial globe, the constellations and fixed stars, all in their relative positions.

A Constellation is a group of fixed stars represented under the name of some emblem or animal.

In representing the relative positions of the earth and the heavens by means of "Williamson's Concentric Globes," the celestial globe is transparent, and surrounds the terrestrial; they turn on a common axle, and have a common centre, and are supported in a brass ring called the Celestial Brazen Meridian.

The earth turns on her axis from west to east once in twenty-four hours, producing an apparent motion of the heavens from east to west; this is called the Diurnal motion.

The diurnal motion of the earth may be represented

by causing the terrestrial globe to revolve from west to east by means of the milled head at the southern extremity of the axle, and the apparent daily motion of the heavens by causing the celestial globe to revolve from east to west by means of the milled head at the northern extremity of the axle.

The AXIS of the earth is an imaginary line passing through her centre upon which she is supposed to revolve, and is represented on the terrestrial globe by the axle on which it revolves.

The TERRESTRIAL POLES are two imaginary points where the axis is supposed to cut the surface of the earth: that which is north is called the NORTH POLE, and that south, the SOUTH POLE. These points are seen on the terrestrial globe where the axle penetrates the surface.

The CELESTIAL POLES are two imaginary points in the heavens exactly over the terrestrial poles, around which the heavenly bodies appear to move, and are seen on the celestial globe where the axle penetrates its surface.

Certain GREAT and SMALL CIRCLES are drawn on the celestial and terrestrial globes representing circles supposed to have been drawn on the celestial and terrestrial spheres for the purpose of measurement, and of determining the position of places and heavenly bodies.

GREAT CIRCLES are those whose planes divide the globe into two equal parts.

SMALL CIRCLES are those whose planes divide the globe into two unequal parts.

The great circles drawn on the globes are the EQUATOR, the ECLIPTIC, the MERIDIAN CIRCLES, and the COLURES.

The small circles drawn on the globes are the TROPICS, the POLAR CIRCLES, and PARALLELS.

The EQUATOR is a great circle which divides the globe into NORTHERN and SOUTHERN HEMISPHERES, and is every where equidistant from the poles.

When applied to the heavens, or the celestial globe, the equator is called the EQUINOCTIAL.

The ECLIPTIC is a great circle whose plane cuts that of the equator at an angle of 23° 28′, and represents the plane of the earth's *orbit.*

MERIDIAN CIRCLES are great circles which pass through the poles, crossing the equator at right angles.

A MERIDIAN is half of a meridian circle, and extends from pole to pole.

The TROPICS are small circles parallel to the equator, and 23° 28′ from it. That which is north of the equator is called the TROPIC of CANCER, and that south the TROPIC of CAPRICORN.

The POLAR CIRCLES are small circles parallel to the equator, and 23° 28′ from the poles. That which is north of the equator is called the ARTIC CIRCLE, and that south the ANTARCTIC CIRCLE.

PARALLELS of LATITUDE are small circles parallel to the equator.

The CELESTIAL BRAZEN MERIDIAN is divided into 360°, numbered from 0° to 90° from the equator to the poles.

The TERRESTRIAL BRAZEN MERIDIAN is a semicircle of brass extending from the north to the south pole of the terrestrial globe, and is divided into 180°, numbered from 0° to 90° from the equator to the poles.

The ZODIAC on the celestial globe is a space extending about 8° on each side of the ecliptic, within which

the apparent motions of the sun, moon, and greater planets are confined.

The COLURES are two imaginary great circles which intersect each other at the celestial poles, one of which crosses the ecliptic at the first degrees of Aries and Libra, and is called the EQUINOCTIAL COLURE because the equinoctial also crosses the ecliptic at these points; the other crosses the ecliptic at the first degrees of Cancer and Capricornus, and is called the SOLSTITIAL COLURE.

The HOUR CIRCLE is a small circle of brass attached to the north pole of the celestial globe, and capable of being moved on the axle. It is divided into twenty-four equal parts or hours, and when moved in connection with the globe, the celestial brazen meridian serves as an index.

Around the north pole of the terrestrial globe an hour circle is mapped, and when this globe is revolved the terrestrial brazen meridian serves as an index.

The SENSIBLE HORIZON is the circle bounding the view of the observer by the apparent meeting of the earth and sky.

The RATIONAL HORIZON is a great circle whose plane passes through the centre of the earth parallel to the plane of the sensible horizon, and which separates the visible from the invisible hemispheres of the heavens.

The UNIVERSAL HORIZON is a flat ring of brass, divided into two separate semicircles, which are suspended on two forked arms between the terrestrial and celestial globes, and which represents the rational horizon. It is divided into three concentric circles, the exterior of which is marked AMPLITUDE, and contains 360°, numbered from the east and west points to the poles from 0° to 90°.

The central circle is marked AZIMUTH, and also contains 360°, and is numbered from the north and south points toward the east and west from 0° to 90°.

The interior circle is divided into 32 parts, which represent the points of the compass; these are subdivided into halves and quarters.

The CARDINAL POINTS of the horizon are EAST, WEST, NORTH, and SOUTH.

The MARINER'S COMPASS attached to the globes, and which represents the sensible horizon, is a circular brass box containing a card divided into 32 points, and fixed on a magnetic needle which points toward the north.

The QUADRANT of ALTITUDE is a thin, flexible strip of brass, divided upward from 0° to 90°, and downward from 0° to 18°, and capable of being screwed to the celestial brazen meridian. The upper divisions are used for determining the distances between heavenly bodies, their altitudes, etc., and the lower divisions for finding the beginning, duration, and end of twilight.

ZONES are five spaces or belts, into which the surface of the earth is divided by the two tropics and the two polar circles. The TORRID ZONE is that space included between the two tropics, and is 46° 56′ in width.

That included between the tropic of Cancer and the arctic circle is called the NORTH TEMPERATE ZONE, which is 43° 4′ in width, and that between the tropic of Capricorn and the antarctic circle the SOUTH TEMPERATE ZONE, which also is 43° 4′ in width.

The space between the arctic circle and the north pole is called the NORTH FRIGID ZONE, and that between the antarctic circle and the south pole the SOUTH FRIGID ZONE, and are each 46° 56′ in width.

LATITUDE on the terrestrial globe is the distance

north or south of the equator; on the celestial globe, the distance north or south of the ecliptic.

The greatest latitude of a place is 90°. The sun, being always on the ecliptic, can have no latitude. The greatest latitude of a planet is 8°, and of a star 90°.

The latitude of a place is measured on the terrestrial brazen meridian; of a heavenly body, on the quadrant of altitude toward the pole of the ecliptic.

Longitude of a place is its distance east or west of the first meridian, measured on the equator half way around the globe; of a heavenly body, its distance from the first point of Aries, measured on the ecliptic eastward around the globe.

The greatest longitude of a place is 180°; of a heavenly body, 360°.

The length of a degree of latitude is in every place 60 geographical miles, but the length of a degree of longitude varies from 60 geographical miles at the equator to nothing at the poles.

Table showing the Length of a Degree of Longitude on any Parallel of Latitude between the Equator and the Poles.

Deg. of Lat.	Geographical Miles.	Deg. of Lat.	Geographical Miles.	Deg. of Lat.	Geographical Miles.	Deg. of Lat.	Geographical Miles.
1	59.99	11	58.90	21	56.01	31	51.43
2	59.96	12	58.69	22	55.63	32	50.88
3	59.92	13	58.46	23	55.23	33	50.32
4	59.85	14	58.22	24	54.81	34	49.74
5	59.77	15	57.96	25	54.38	35	49.15
6	59.67	16	57.67	26	53.93	36	48.54
7	59.55	17	57.38	27	53.46	37	47.92
8	59.42	18	57.06	28	52.98	38	47.28
9	59.26	19	56.73	29	52.48	39	46.63
10	59.09	20	56.38	30	51.96	40	45.96

Deg. of Lat.	Geographical Miles.	Deg. of Lat.	Geographical Miles.	Deg. of Lat.	Geographical Miles.	Deg. of Lat.	Geographical Miles.
41	45.28	54	35.27	67	23.44	79	11.45
42	44.59	55	34.41	68	22.48	80	10.42
43	43.88	56	33.55	69	21.50	81	9.39
44	43.16	57	32.68	70	20.52	82	8.35
45	42.34	58	31.80	71	19.53	83	7.31
46	41.68	59	30.90	72	18.54	84	6.27
47	40.92	60	30.00	73	17.54	85	5.23
48	40.15	61	29.09	74	16.54	86	4.19
49	39.36	62	28.17	75	15.53	87	3.14
50	38.57	63	27.24	76	14.52	88	2.00
51	37.76	64	26.30	77	13.50	89	1.05
52	36.94	65	25.36	78	12.47	90	0.00
53	36.11	66	24.40				

DECLINATION is the distance of a heavenly body north or south from the equinoctial.

The greatest declination of the sun is 23° 28′; of a planet, about 31½°; and of a star, 90°.

If the heavenly body be north of the equinoctial, it has NORTH DECLINATION; and if south, SOUTH DECLINATION.

The ELEVATION OF THE POLE at any place is the height of the pole above the horizon, measured on the celestial brazen meridian. It is always the same number of degrees as the latitude of the place.

RIGHT ASCENSION of a heavenly body is its distance east from the first point of Aries, measured on the equator.

Declination and right ascension in the heavens correspond to latitude and longitude on the earth.

The ZENITH is that point in the heavens directly overhead of the observer, and is 90° from every point in the horizon.

The NADIR is that point in the heavens directly opposite to the zenith.

Vertical Circles are circles supposed to be drawn through the zenith and nadir of any place, cutting the horizon at right angles.

The Prime Vertical is that which passes through the east and west points of the horizon, cutting the meridian at right angles.

The Azimuth of a heavenly body is that arc of the horizon intercepted between a vertical circle passing through the object, and the north or south points of the horizon.

Amplitude of a heavenly body is that arc of the horizon comprehended between an object at rising or setting, and the east or west points of the horizon.

Parallels of Celestial Latitude are small circles drawn on the celestial globe parallel to the ecliptic.

The Altitude of a heavenly body is an arc of a vertical circle intercepted between that body and the horizon.

When the heavenly body is on the meridian, this arc is called the Meridian Altitude.

The Zenith distance of a heavenly body is an arc of a vertical circle comprehended between that body and the zenith.

The Polar distance of a heavenly body is an arc of a meridian comprehended between that body and the equinoctial pole.

The Amphiscii are the inhabitants of the torrid zone so called, because their shadows at noon point north or south at different seasons of the year.

The Heteroscii are the inhabitants of the temperate zone so called, because their shadows at noon always point in the same direction.

The Periscii are those who inhabit the frigid zones,

because their shadows during a revolution of the earth on her axis point to all points of the horizon.

The Antœci are those who have the same degree of longitude and equal degrees of latitude, but one north and the other south of the equator.

The Periœci are those who have the same latitude, but opposite longitudes.

The Antipodes are those who live diametrically opposite to each other.

Crepusculum, or Twilight, is that faint light which we perceive before the sun rises and after he sets. It is seen in the evening until the sun has descended 18° below the horizon, and in the morning when the sun is again within 18° of the horizon.

The ecliptic and zodiac are divided into twelve equal parts called Signs, which bear the names of the constellations which formerly corresponded with them. Each sign is divided into thirty equal parts or degrees.

The signs of the zodiac do not now correspond with the constellations of the zodiac, the difference between them being about thirty degrees. The sign Aries commences where the ecliptic is crossed by the equinoctial colure, while the constellation Aries commences about thirty degrees more to the east.

Owing to the motion of the earth in her orbit, the sun has an apparent motion in the heavens passing through the signs of the zodiac in succession from west to east at the rate of one degree nearly each day.

The names of the signs, and the days on which the sun enters them, are as follows:

Spring Signs.	
♈ Aries, the Ram, March 21st.	Northern Signs.
♉ Taurus, the Bull, April 19th.	
♊ Gemini, the Twins, May 20th.	

Summer Signs.

♋ Cancer, the Crab, June 21st.
♌ Leo, the Lion, July 22d.
♍ Virgo, the Virgin, August 22d.

} Northern Signs.

Autumn Signs.

♎ Libra, the Balance, September 23d.
♏ Scorpio, the Scorpion, October 23d.
♐ Sagittarius, the Archer, November 22d.

Winter Signs.

♑ Capricornus, the Goat, December 21st.
♒ Aquarius, the Waterman, January 20th.
♓ Pisces, the Fishes, February 19th.

} Southern Signs.

The first degrees of the signs Cancer and Capricornus are called the SOLSTITIAL POINTS, because the sun when at these points appears for some days to stand still—that is, he does not increase or diminish his declinations: the former is called the SUMMER SOLSTICE, and the latter the WINTER SOLSTICE.

The ANGLE of POSITION between two places on the earth is an angle at the zenith of one of the places formed by the meridian of that place and a vertical circle passing through the other place, measured on the horizon from the elevated pole toward the vertical circle.

The angle of position of a heavenly body is an angle formed by two great circles intersecting each other in the place of the heavenly body, the one passing through the pole of the ecliptic, the other through the equinoctial pole.

The DIURNAL ARC is the arc described by a heavenly body from its rising to its setting.

The NOCTURNAL ARC is the arc described by a heavenly body from its setting to its rising.

Aberration is an apparent motion of celestial bodies, caused by the earth's motion in her orbit, combined with the progressive motion of light.

POSITIONS OF THE SPHERE.

A Right Sphere is that position of the earth where the equinoctial passes through the zenith and nadir, the poles being at the horizon. It is so called because the parallels of latitude cut the horizon at *right* angles. The inhabitants who live at the equator enjoy this position of the sphere. In this position it will be observed that the diurnal and nocturnal arches of any heavenly body are equal; consequently the days and nights are of equal lengths.

The Parallel Sphere is that position of the earth where the parallels of latitude are *parallel* to the horizon. The inhabitants (if any) who live at the poles have this position. The sun appears above the horizon for six months together.

The Oblique Sphere is that position of the earth where the parallels of latitude cut the horizon obliquely. All the inhabitants of the earth, except those at the equator and at the poles (if any), have this position. It will be observed that in this position the parallels are each divided by the horizon into two unequal parts; hence the days and nights are of unequal lengths, except when the sun is on the equinoctial.

When either pole is elevated above the horizon, there is a certain circle, having this pole for its centre, and its altitude for radius, wherein the stars do not sink beneath the horizon; this is called the Circle of Perpetual Apparition.

A circle of precisely similar dimensions surrounds the depressed pole, wherein the stars do not rise above

the horizon, which is called the CIRCLE OF PERPETUAL OCCULTATION.

The ANALEMMA is a table usually in the shape of the figure 8 on the terrestrial globe, extending from the tropic of Cancer to the tropic of Capricorn, used for ascertaining the sun's declination on any day in the year.

The CIRCLE of ILLUMINATION is that great circle which divides the hemisphere presented to the sun from the hemisphere which is deprived of his light.

CHAPTER II.

PROBLEMS ON THE TERRESTRIAL GLOBE.

PROBLEM I.

To find the latitude of any given place.

RULE.—Cause the terrestrial globe to revolve by turning the milled screw at the south pole of the celestial globe untii the given place is brought under the graduated side of the terrestrial brazen meridian; the degree above the place is the latitude.

When a place is north of the equator, it is in north latitude; when south, south latitude.

Examples.—Find the latitude of the following places:

London,	*Ans.*	51° 31′ N.	Washington,	*Ans.*	38° 53′ N.
New York,	"	40° 43′ N.	Madrid,	"	40° 25′ N.
Calcutta,	"	22° 33′ N.	Paris,	"	48° 50′ N.
Valparaiso,	"	33° 2′ S.	Vienna,	"	48° 12′ N.

PROBLEM II.

To find those places which have the same latitude as any given place.

RULE.—Find the latitude of the given place by Problem I. Cause the terrestrial globe to revolve, and all places passing under this latitude on the terrestrial brazen meridian will be those required.

Note.—All places in the same latitude have the same length of day and night, and the same seasons of the year.

Find the principal places which have the same or nearly the same latitude as Canton.

Answer. Calcutta, Havana.

Name some places where the length of each day in the year corresponds with that at New York.

Answer. Naples, Constantinople.

Name some places where the seasons correspond with those at Edinburg.

Answer. Copenhagen, Moscow.

PROBLEM III.

To find the longitude of any given place.

RULE.—Bring the given place under the graduated side of the terrestrial brazen meridian; its longitude will be found on the equator where it is crossed by this meridian.

When the given place is east of the meridian which passes through Greenwich, near London, it is in east longitude; when west, in west longitude.

Find the longitude of the following places:

London,	*Answer.*	0°	0′	E. or W.
New York,	"	74°	0′	W.
Calcutta,	"	88°	19′	E.
Valparaiso,	"	71°	42′	W.
Washington,	"	77°	3′	W.
Madrid,	"	3°	45′	W.
Paris,	"	2°	20′	E.
Vienna,	"	16°	23′	E.

What is the greatest longitude a place can have?

PROBLEM IV.

To find those places which have the same longitude as a given place.

RULE.—Bring the given place under the graduated side of the terrestrial brazen meridian, and all places under this meridian from north pole to south pole will be those required.

Note.—It will be noon at the same time at all places situated under the same meridian.

Name a place where the longitude is the same, or nearly the same, as that of Stockholm. *Answer.* Dantzic, Cape of Good Hope.

PROBLEM V.

To find the latitude and longitude of any given place.

RULE.—Bring the given place to the graduated side of the terrestrial brazen meridian; the latitude will be found on the meridian over the place, and the longitude on the equator where it is crossed by the meridian.

PROBLEM VI.

To find a place on the globe, its latitude and longitude being given.

RULE.—Bring that longitude on the equator which corresponds with the longitude of the given place to the graduated side of the terrestrial brazen meridian, and under the given latitude on the meridian will be found the place required.

What places have the following latitudes and longitudes?

Lat.	Long.		
50° 4′ N.	5° 45′ W.	*Answer.*	Land's End.
48° 12′ N.	16° 23′ E.	"	Vienna.
52° 4′ N.	4° 19′ E.	"	The Hague.
19° 26′ N.	103° 46′ W.	"	Mexico.
42° 21′ N.	71° 4′ W.	"	Boston.
59° 21′ N.	18° 4′ E.	"	Stockholm.

Where on the earth is there neither latitude nor longitude? *Answer.* Where the first meridian crosses the equator.

PROBLEM VII.

To find the difference of latitude between any two places.

RULE.—Find the latitude of each place by Problem I. If both be north or both south, subtract the less from the greater, and the remainder will be the difference of latitude. If one be north and the other south, their sum will be the difference of latitude.

Find the difference of latitude between the following places:

New York and New Orleans, 40° 43′ N.—29° 58′ N. =10° 45′, *Ans.*

London and the Cape of Good Hope, 51° 31′ N. + 34° 22′ S. = 85° 53′, *Ans.*

Quebec and Rio Janeiro, 46° 49′ N. + 22° 55′ S. = 69° 44′, *Ans.*

San Francisco and Valparaiso, 37° 48′ N. + 33° 2′ S. = 70° 50′, *Ans.*

St. Petersburg and New York, 59° 57′ N. − 40° 43′ N. = 19° 14′, *Ans.*

St. Helena and Jamaica, 15° 57′ S. + 17° 40′ N. − 33° 37′, *Ans.*

What two places on the earth have the greatest difference of latitude? *Ans.* The north and south poles.

PROBLEM VIII.

To find the difference of longitude between any two places.

Rule.—Find the longitude of each place by Problem III. If both be east or both west, their difference will be the difference of longitude. If one be east and the other west, their sum will be the difference of longitude.

Find the difference of longitude between the following places:

London and New York, 0° 0′ + 74° 0′ W. = 74° 0′, *Ans.*

Constantinople and Washington, 28° 59′ E. + 77° 3′ W. = 106° 2′, *Ans.*

Rome and Madrid, 12° 27′ E. + 3° 45′ W. = 16° 12′, *Ans.*

Philadelphia and San Francisco, 75° 10′ W. − 122° 26′ W. = 47° 16′, *Ans.*

Calcutta and New Orleans, 88° 19′ E. + 90° 7′ W. = 178° 26′, *Ans.*

Dublin and Boston, 6° 20′ W. − 71° 4′ W. = 64° 44′, *Ans.*

PROBLEM IX.

To find the difference of time between any two given places.

RULE.—Find the difference of longitude between the given places by Problem VIII.

Every degree of difference of longitude is equal to four minutes difference of time, and every fifteen degrees to one hour. Or,

Multiply the difference of longitude in degrees and minutes by 4, and the product will be the difference of time in minutes and seconds.

Find the difference of time between the following places:

	Diff. of Long.	Diff. of Time. *h.* *m.* *sec.*	
London and Washington,	77° 3′ =	5 8 12	*Ans.*
Constantinople and N. York,	102° 59′ =	6 51 56	"
Calcutta and San Francisco,	200° 45′ =	13 23 0	"
Rio Janeiro and Lima,	33° 57′ =	2 15 48	"
St. Petersburg and Paris,	27° 59′ =	1 51 56	"
Boston and San Francisco,	116° 6′ =	7 44 24	"

PROBLEM X.

The time at any given place being given, to find the time at any other given place.

RULE.—Find the difference of time between the two given places by Problem IX.; and if the place whose time is sought lie to the east of the place whose time is given, add the difference of time to the given time; but if it lie to the west, subtract it.

1. When it is 10 o'clock A.M. at New York, what time is it at London?

Longitude at New York, 74° 0′ W.
" " London, 0° 0′

Difference of longitude, 74° 0′.

Difference of time, 4 hours 56 minutes 9 seconds.

Time at New York, 10 hours 0 min.
Difference of time, 4 " 56 "

14 hours 56 min. = — 2 hours 56 minutes after 12 o'clock.

Answer. 56 minutes past 2 P. M.

2. When it is midnight at Boston, what hour is it at Botany Bay?

Longitude of Boston, 71° 4′ W.
" " Botany Bay, 151° 15′ E.

Difference of longitude, 222° 19′.

Difference of time, 14 hours 49 minutes 16 seconds.

Subtracting 12 hours brings the time to noon of January 1st, and then subtracting 2 hours 49 minutes 16 seconds from 12 hours gives 9 hours 10 minutes 44 seconds. *Answer.* 10 minutes 44 seconds past 9 o'clock A.M., January 1st.

3. When it is noon at Washington, what is the hour at the Cape of Good Hope?

Longitude of Washington, 77° 3′ W.
" " Cape of Good Hope, 18° 29′ E.

Difference of longitude, 95° 32′.

Difference of time, 6 hours 22 minutes 8 seconds.

Subtracting the difference in time from 12 o'clock, we get 5 hours 37 minutes 52 seconds. *Answer.* 37 minutes 52 seconds past 5 A.M.

PROBLEM XI.

To find the Antœci, Periœci, and Antipodes to the inhabitants of any given place.

RULE.—Bring the globes to the position of a right sphere, and turn the terrestrial globe until the given place is at the eastern half of the brazen horizon.

Find on the amplitude circle the number of degrees the given place is north or south of the east point on the horizon.

1st. The ANTŒCI will be situated opposite that point which is numbered as many degrees on the amplitude circle on the other side of the east point of the horizon.

2d. The PERIŒCI will be situated opposite that point of the western half of the horizon which numbers as many degrees on the amplitude circle in the same direction from the west point of the horizon.

3d. The ANTIPODES will be situated opposite that point of the western half of the horizon which numbers as many degrees on the amplitude circle in the opposite direction from the west point of the horizon.

Find the Antœci of the following places, viz.:

1. Falkland Islands. *Ans.* Eastern part of Labrador.
2. Bermuda Islands.
3. Cairo, in Egypt.
4. Jeddo.
5. Bourbon Island.
6. New York.
7. Bombay.

Find the Periœci of the following places:

8. St. Thomas Island. *Ans.* Hong Kong Island.
9. Calcutta.
10. Luzon.
11. Bermuda Islands.
12. Cape of Good Hope.

Required the Antipodes to the following places:

13. Marquesas Islands. *Ans.* Central part of Abyssinia.

14. Dublin.
15. Moscow.
16. Christiana.
17. Isthmus of Suez.
18. San Francisco.
19. New Zealand.

PROBLEM XII.

The difference of time between two places being given, to find their difference of longitude.

Rule.—Reduce the difference of time to minutes, and divide by 4; multiply the remainder, if any, by 60, and divide the product by 4; the quotients will be the difference of longitude in degrees and minutes.

Reduce the following differences of time to differences of longitude:

1. 4 hours 16 minutes. *Ans.* 64 degrees.
2. 21 " 11 "
3. 14 " 15 "
4. 3 " 50 "
5. 6 " 11 "
6. 1 " 45 "

7. The difference of time between London and New York is 4 hours 56 minutes; what is their difference of longitude?

8. When it is 12 o'clock noon at Liverpool, it is 3 minutes past 4 A.M. at San Francisco; what is their difference of longitude?

PROBLEM XIII.

A particular place, and the hour at that place, being given, to find all places on the globe where it is any other given hour.

Rule.—Find the difference of time between the given place and the place to be found. Reduce this dif-

ference of time to difference of longitude by Problem XII. If the hour of the required places be earlier than that of the given place, the required places will lie so many degrees west of the given place; but if later, to the east.

1. When it is 12 o'clock noon at Hong Kong, at what places is it half past 6 A.M.?

2. When it is 3 P.M. at Port Philip, where is it midnight?

3. When it is half past 5 P.M. at Constantinople, where is it 3 P.M.?

4. When it is 10 A.M. at Edinburg, where is it 10 P.M.?

5. When it is 7 A.M. at Florence, where is it 10 A.M.?

6. When it is noon at the Straits of Gibraltar, where is it 9 A.M.?

PROBLEM XIV.

To find the sun's declination, and his longitude, or place on the ecliptic, for any given day.

RULE.—Bring the given day on the analemma under the graduated side of the terrestrial brazen meridian; the degree on the meridian immediately over it will be the sun's declination for the given day.

Turn the globe around until a point in the ecliptic passes under that degree on the meridian which shows the sun's declination; that point will be the sun's longitude or place for the given day.

If the given day be between March 21st and June 21st, the sun's place will be between Aries and Cancer; if between June 21st and September 23d, it will be between Cancer and Libra; if it be between September 23d and December 21st, between Libra and Capricor-

nus; and if it be between December 21st and March 21st, it will be between Capricornus and Aries.

1. What is the sun's longitude and declination on the 21st of June? *Ans.* 1st degree of ♋ (Cancer); declination 23 degrees 28 minutes.

Find the sun's longitude and declination for the following days:

2. January	4th.	3. February	11th.
4. March	8th.	5. April	15th.
6. May	28th.	7. June	19th.
8. July	16th.	9. August	7th.
10. September	1st.	11. October	4th.
12. November	8th.	13. December	25th.

PROBLEM XV.

To rectify the terrestrial globe for any given latitude.

Rule.—Bring that degree which corresponds with the given latitude, and which is marked on the lower half of the opposite side of the celestial brazen meridian, to the index on the stand. If the latitude be north, the north pole will be elevated; and if south, depressed below the horizon a number of degrees corresponding with the given latitude.

1. What is the altitude of the north polar star at Montreal? *Ans.* 45° 30′.

2. What is the altitude of the north pole at Lisbon? *Ans.* 38° 42′.

3. What is the altitude of the south pole at the Cape of Good Hope? *Ans.* 34° 22′.

PROBLEM XVI.

The month and day of the month being given, to find all those places where the sun is vertical; those places where the sun does not set, and those places where the sun does not rise on the given day.

Rule. — Find the sun's declination for the given month and day by Problem XIV., and observe the degree which corresponds with it on the terrestrial brazen meridian. Elevate the north pole if the declination be north, and the south pole if south, to an altitude corresponding in degrees with the declination.

Turn the terrestrial globe on its axis from west to east.

1st. The sun will be vertical on that day to all those places which passes under the declination on the terrestrial brazen meridian.

2d. The sun does not set on that day to those places lying near the elevated pole, and which do not sink below the horizon.

3d. The sun does not rise on that day to those places near the depressed pole which do not ascend above the horizon.

1. At what places is the sun vertical on May 1st?

Ans. At all those places having 15° north latitude.

2. Where in the north frigid zone does the sun not set on August 10th?

Ans. At all places north of 70° north latitude.

3. Where in the south frigid zone does the sun not rise on the 1st of June.

Ans. South of 68° south latitude.

4. At what places is the sun vertical on Dec. 25th?

5. " " " " March 3d?

6. Where in the north frigid zone does the sun not set on April 3d?

7. Where in the south frigid zone does the sun not rise on April 12th?

9. Where in the south frigid zone does the sun not rise on May 8th?

PROBLEM XVII.

To find those two days of the year on which the sun will be vertical at a given place in the torrid zone.

RULE.—Turn the terrestrial globe until the analemma passes under the latitude of the given place on the terrestrial brazen meridian. The two days will be found on the analemma under that degree on the meridian corresponding with the latitude of the given place.

1. In latitude 10° north, the sun is vertical on April 15th; on what other day of the year will he be vertical in the same latitude? *Ans.* August 28th.

2. The sun is vertical at 20° south latitude on November 21st; on what day will he again be vertical at the same place? *Ans.* January 22d.

3. On what two days of the year will the sun be vertical in north latitude 15°? *Ans.* May 2d and August 11th.

PROBLEM XVIII.

At any given place not in the frigid zones, the month and day of the month being given, to find what other day in the year is of the same length.

RULE.—Find the given month and day on the analemma; the required month and day will be found opposite to it, on the other side of the analemma.

1. What other day in the year at London will be the same length as March 3d. *Ans.* October 10th.

2. At Trieste, what day in the year will correspond in length with February 28th? *Ans.* October 13th.

3. What day at Jerusalem will correspond in length with December 25th? *Ans.* December 19th.

PROBLEM XIX.

The month, day, and hour at any place being given, to find that place at which the sun is vertical.

Rule.—Find the sun's place on the ecliptic for the given month and day by Problem XIV., and note that degree on the terrestrial brazen meridian which shows his declination. Reduce the difference of time between the given hour and noon to degrees and minutes by Problem XII. Bring the given place to the terrestrial brazen meridian, and if the given time be earlier than noon, turn the terrestrial globe west, and if later, east, a number of degrees corresponding with the difference of time reduced to degrees, etc.; the given place will be found under that degree on the meridian which shows the sun's declination.

1. When it is 40 minutes past 6 in the morning at London on August 10th, where is the sun vertical? *Ans.* Lat. 15° 30′ north, long. 80° east, southeastern part of Hindostan.

2. When it is 3 P.M. at Charleston, May 8th, where is the sun vertical? *Ans.* Lat. 16° north, long. 124° 57′ west, in the Pacific Ocean.

3. When it is 8 A.M. at Bombay on November 12th, where is the sun vertical? *Ans.* Lat. 18° south, long. 133° 30′ east, northern part of Australia.

4. When it is 5 A.M. at San Francisco, March 30th, where is the sun vertical? *Ans.* Lat. 3° 30′ north, long. 16° 20′ west, Atlantic Ocean.

PROBLEM XX.

The month, day, and hour at any place being given, to find, 1*st, all those places on the earth where the sun is rising;* 2*d, those places where the sun is setting;* 3*d, those that have noon;* 4*th, that particular place where the sun is vertical;* 5*th, those places that have morning twilight;* 6*th, those places that have evening twilight; and,* 7*th, those places that have midnight.*

Rule.—Find the sun's declination by Problem XIV., and note it on the terrestrial brazen meridian. If the declination be north, elevate the north pole, and if south, the south pole, a number of degrees corresponding with the sun's declination. Bring the given place to the terrestrial brazen meridian. Reduce the difference of time between the given hour and noon to degrees and minutes by Problem XII. If the given hour be earlier than noon, turn the terrestrial globe west, and if later, east, a number of degrees corresponding with the difference of time reduced to degrees and minutes.

1st. All those places along the western edge of the horizon have the sun rising.

2d. All those places along the eastern edge of the horizon have the sun setting.

3d. All those places under the terrestrial brazen meridian and above the horizon have noon.

4th. That particular place under the sun's declination on the terrestrial brazen meridian has the sun vertical.

5th. All those places below the western edge of the horizon, and within 18° of it, have morning twilight.

6th. All those places below the eastern edge of the horizon, and within 18° of it, have evening twilight.

7th. All those places under that portion of the meridian circle passing through the given place which is below the horizon have midnight.

1. When it is 7 A.M. at Washington on February 17th, where is the sun rising, setting, etc?

Ans. 1st. Sun rising centre of Greenland and Labrador, states of Ohio, Kentucky, and Louisiana, Gulf of Mexico, Yucatan, and Central America.

2d. Sun setting in eastern part of Russia in Europe and of Independent Tartary, and central part of Hindostan.

3d. Noon west of Africa, central part of Spain, N.E. part of Ireland.

4th. Sun vertical at latitude 12° south, longitude 2° west.

5th. Morning twilight at Melville Island, central part of British America, and along the Rocky Mountain ridge.

6th. Evening twilight at central part of Liberia and Chinese Empire, Burmah, and at the western part of Australia.

7th. Midnight at Kamtschatka, New Zealand, and Fiji Islands.

PROBLEM XXI.

To find the time of the sun's rising and setting, and the length of day and night on any given day at any given place not in the frigid zone.

Rule.—Find the sun's declination for the given day by Problem XIV. If it be north, elevate the north pole, and if south, the south pole, a number of degrees above the horizon corresponding with the declination, and bring the given place to the graduated side of

the terrestrial brazen meridian. On a parallel passing through the given place, ascertain how many degrees lie between the meridian and the eastern part of the horizon, and reduce these degrees to hours by Problem IX. 1st. These hours subtracted from 12 will give the time of the sun's rising. 2d. These hours will be the time after 12 when the sun sets. 3d. Double these hours will be the length of the day. 4th. The length of the day subtracted from 24 will give the length of the night.

1. At what time does the sun rise and set at Moscow on July 23d, and what is the length of the day and night?

Ans. Sun rises at 4 A.M. and sets at 8 P.M.; length of day, 16 hours; length of night, 8 hours.

2. Required the length of the longest day and shortest night at Berlin.

Ans. Longest day, 16 hours 12 minutes; shortest night, 7 hours 48 minutes.

3. Required the length of the shortest day and longest night at Lima.

Ans. Shortest day, 11 hours 20 minutes; longest night, 12 hours 40 minutes.

PROBLEM XXII.

The length of the day at any place not in the frigid zones being given, to find the sun's declination, and the month and day of the month.

RULE.—With the north and south poles of the terrestrial globe at the horizon, bring the given place to the graduated side of the terrestrial brazen meridian; then turn the globe eastward as many degrees as are equal to half the length of the day reduced to degrees by Problem XII.

Keep the terrestrial globe from revolving on its axis by screwing the milled head at the south of the axle. Elevate or depress the north pole until the given place is brought to the eastern edge of the horizon. The altitude of the north or south pole will correspond with the sun's declination in degrees. If the north pole be elevated the declination will be north, and if the south pole be elevated it will be south. Note this declination on the terrestrial brazen meridian, and bring the analemma under it, when the months and days of the months will be seen.

1. What two days of the year are each 14 hours in length at Rome, and what is the sun's declination on those days?

Ans. May 9th and August 14th; declination, 17° 30′ north.

2. On what two days does the sun at New Orleans rise at 5 A.M. and set at 7 P.M.?

Ans. March 21st and September 23d.

3. On what two days at St. Petersburg does the sun rise at 4 A.M. and set at 8 P.M.?

Ans. May 12th and August 2d.

PROBLEM XXIII.

To find when constant day begins and ends at any given place in the north frigid zone.

Rule.—Find the latitude of the given place by Problem I., and subtract it from 90°. Find on the terrestrial brazen meridian a north declination corresponding in degrees with this difference; those days and months on the analemma which will pass under this declination will be the days required.

1. What is the length of the day, and when does it begin and when end at South Cape, Spitzbergen?

Ans. Length of constant day, 120 days; begins April 8th, ends August 20th.

2. Find the beginning, end, and duration of constant day at Cape Bathurst.

Ans. Length of constant day, 65 days; begins May 20th, ends July 24th.

3. Find the beginning, end, and duration of constant day at Disco Island.

Ans. Length of constant day, 61 days; begins May 22d, ends July 22d.

PROBLEM XXIV.

To find when constant night begins and ends, and its duration, at any given place in the north frigid zone.

RULE.—Find the latitude of the given place by Problem I., and subtract it from 90°. Find on the terrestrial brazen meridian a south declination corresponding in degrees with this difference; those days on the analemma which will pass under this declination will be the days required.

1. What is the length of constant night, and when does it begin and when end at the eastern extremity of Nova Zembla?

Ans. It begins on October 31st, and ends on February 22d; duration, 115 days.

2. Find the beginning, end, and duration of constant night at North Somerset Island.

Ans. Constant night begins November 9th, and ends February 2d; duration, 85 days.

3. Find the beginning, end, and duration of constant night at Cape Taimar, in Asia.

Ans. Constant night begins October 27th, and ends February 15th; duration, 111 days.

PROBLEM XXV.

To find the days, and number of days, on which the sun rises and sets every 24 hours, at any given place within the north frigid zone.

RULE.—Find the beginning, end, and duration of constant day at the given place by Problem XXIII. Find also the beginning, end, and duration of constant night by Problem XXIV. The sun will rise and set every 24 hours on those days which are between those showing the end of constant day and the beginning of constant night, also on those between the end of constant night and beginning of constant day.

Add together the lengths of constant day and constant night, and subtract the sum from 365; the remainder will show the number of days in the year on which the sun will rise and set every 24 hours at the given place.

1. On how many days of the year does the sun rise and set at Greenland, in 70° north latitude?

Ans. Constant day from May 21st till July 24th.

Constant night from November 21st till January 22d; from July 24th till November 21st, 120 days; from January 22d till May 21st, 119. Total, 239 days.

2. How many days in the year does the sun rise and set at the North Cape, in the Island of Maggeroe, latitude 71° 30′ north? *Ans.* 215 days.

3. On how many days in the year does the sun rise and set at the north of Spitzbergen? *Ans.* 107 days.

PROBLEM XXVI.

To find in what degree of north latitude the sun begins to shine constantly on any given day between the 21*st of March and the* 21*st of June; also in what degree in south latitude on any given day between the* 23*d of September and the* 21*st of December.*

Rule.—Find the sun's declination for the given day by Problem XIV., and subtract the number of degrees expressing it from 90; the difference will be the required latitude.

1. In what degree south latitude does the sun begin to shine constantly on the 18th of October? *Ans.* 80° south latitude.

2. In what degree south latitude does the sun begin to shine without setting on November 20th? *Ans.* 70° south latitude.

3. In what degree north latitude does the sun begin to shine without setting on May 1st? *Ans.* 76° north latitude.

PROBLEM XXVII.

Any number of days not exceeding 186 *being given, to find that latitude at which the sun does not set for the given number of days.*

Rule.—Count half the number of days backward or forward on the analemma from the 21st of June or the 22d of December, and bring the last day thus found under the terrestial brazen meridian, on which will be found the sun's declination for that day; subtract this declination from 90°, and the remainder will be the latitude required.

1. In what degree does the sun shine for 150 days? *Ans.* 84° north or south latitude.

2. In what latitude does the sun shine for 100 days? *Ans.* 76° north or south latitude.

3. In what latitude does the sun shine for 60 days? *Ans.* 70° 20′ north or south latitude.

PROBLEM XXVIII.

To place the terrestrial globe in a similar situation with respect to the sun as the earth is at the equinoctial, and at the summer and winter solstices, and thereby to show the comparative lengths of the days and nights at the different seasons of the year.

Rule.—1st. For the Equinoxes.—Since the sun at the equinoxes is vertical at the equator, rectify the globe for latitude 0° by Problem XV. The inner edge of the brazen horizon will represent the circle of illumination, which in this case extends from pole to pole, crossing the equator at right angles. And since all great circles on a globe mutually bisect each other, the circle of illumination will at this and all other seasons bisect the equator; hence the diurnal arch will at the equator be at all times equal to the nocturnal arch, and the days and nights each 12 hours long. But at this season the circle of illumination bisects also every parallel from the north to the south pole; hence the days and nights are equal over the whole world.

2d. For the Summer Solstice.—At the summer solstice the sun is vertical at 23° 28′ north latitude. Rectify the globe for this latitude by Problem XV., when it will be observed, 1st. That some parallels near the south pole, viz., those south of 66½° south latitude, do not come within the circle of illumination at any

part of the day, as may be illustrated by causing the globe to revolve on its axis. In these latitudes there is constant night. 2d. That those parallels between the equator and $66\frac{1}{2}^\circ$ south latitude are unequally divided by the circle of illumination, making the nocturnal arch greater than the diurnal arch; hence the nights are longer than the days in the ratio of the length of the nocturnal arch to the length of the diurnal arch. 3d. That those parallels between the equator and $66\frac{1}{2}^\circ$ north latitude are unequally divided by the circle of illumination, the diurnal arch being greater than the nocturnal: consequently the days are longer than the nights in the ratio of the diurnal to the nocturnal arch. 4th. That those parallels north of $66\frac{1}{2}^\circ$ north latitude are altogether within the circle of illumination, as may be illustrated by causing the globe to revolve on its axis. In these latitudes there is constant day.

3d. For the Winter Solstice.—The same explanations as those for the summer solstice will answer in this case, by simply substituting north for south, south for north, day for night, and night for day.

CHAPTER III.

PROBLEMS TO BE PERFORMED WITH THE TERRESTRIAL AND CELESTIAL GLOBE.

PROBLEM XXIX.

To find the beginning, duration, and end of twilight at any given place on any given day.

RULE.—Find the latitude of the given place by Problem I., and rectify the globes for that latitude by Problem XV. Find the sun's place for the given day on the ecliptic, and bring it under the celestial brazen meridian. Set the hour circle to 12, and screw the quadrant of altitude to the celestial brazen meridian at that degree corresponding with the latitude of the given place. Turn the celestial globe westward on its axis till the sun's place comes to the western edge of the horizon. The hours passed over by the index will show the time of the sun's setting, or the beginning of evening twilight. Continue the motion of the globe westward till the sun's place coincides with 18° on the quadrant of altitude below the horizon. The time passed over by the index from the time of the sun's setting will be the duration of evening twilight.

1. Required the beginning, duration, and end of evening twilight at New Orleans on June 21st. *Ans.* Twilight commences at 15 minutes past 7, and ends at 45 minutes past 8; duration, 1 hour 30 minutes.

2. Required the beginning, duration, and end of evening twilight at Washington on June 21st. *Ans.* Twi-

light commences 20 minutes past 7, and ends 15 minutes past 9; duration, 1 hour 55 minutes.

3. Required the beginning, duration, and end of evening twilight at New York on June 21st. *Ans.* Twilight commences at 7 hours 45 minutes, and ends 9 hours 45 minutes; duration, 2 hours.

4. Required the beginning, duration, and end of evening twilight at Quebec on June 21st. *Ans.* Twilight commences at 8 hours, and ends 10 hours 45 minutes; duration, 2 hours 45 minutes.

PROBLEM XXX.

To find the beginning, duration, and end of constant twilight and day at any given place.

Rule.—To the latitude of the given place add 18°, and subtract the sum from 90. Find on the celestial brazen meridian a declination corresponding in degrees with this difference, and observe what two points on the ecliptic will pass under it. At that one of the two points which shows increasing declination will be found the day on which constant twilight begins, and at that one which shows decreasing declination will be found the day on which constant twilight ends.

1. When do the inhabitants of London have constant day or twilight? *Ans.* From May 22d till July 21st, or 60 days.

2. When do the inhabitants at the north of Scotland have constant twilight or day? *Ans.* From April 28th till August 15th, or 109 days.

3. When do those who live at Frobisher's Straits have constant day or twilight? *Ans.* From April 14th till August 29th, or 137 days.

PROBLEM XXXI.

To find the duration of twilight at the north pole.

RULE.—Elevate the north pole 90°, and, 1st, observe what point in the ecliptic nearest to Libra passes under 18° on the celestial brazen meridian below the horizon. Find on the ecliptic the month and day corresponding with it. The time between September 21st and this day will be the duration of evening twilight. 2d. Observe what point in the ecliptic nearest to Aries passes under 18° on the celestial brazen meridian below the horizon. Find on the ecliptic the month and day corresponding with it. The time between that day and the 21st of March will be the duration of morning twilight.

1. What is the duration of twilight at the north pole, and what is the duration of dark night there? *Ans.* Evening twilight commences at the 23d of September and continues to the 13th of November, being 51 days. Morning twilight commences January 29th and continues to March 21st, being 51 days. From September 23d till March 21st=179 days, from which deduct $51 \times 2 = 179 - 102 = 77$ days total darkness.

PROBLEM XXXII.

To find that part of the equation of time which depends on the obliquity of the ecliptic.

RULE.—Find the sun's place in the ecliptic by Problem XIV., and bring it to the celestial brazen meridian. From the first degree of Aries to the graduated side of the celestial brazen meridian, count the number of degrees both on the ecliptic and the equinoctial. Sub-

tract the less from the greater, and reduce to the difference of time by Problem IX., which will give the equation of time. If the number of degrees on the ecliptic exceed those on the equinoctial, the sun is faster than the clock; but if those on the equinoctial exceed those on the ecliptic, the sun is slower than the clock.

Note.—The difference between a well-regulated clock and a sun-dial depends upon two causes, viz., the obliquity of the ecliptic, and the unequal velocity of the earth in her orbit.

Rule.—Or, find the sun's place on the ecliptic by Problem XIV., and under the sign, and opposite the degree on the following table will be found the equation of time required.

1. What is the equation of time on the 4th of July? *Ans.* In Cancer, 15°; sun slower than clock 5 minutes 9 seconds.

2. What is the equation of time on November 1st? *Ans.* 9° in Scorpio; sun faster than clock 9 minutes 36 seconds.

3. What is the equation of time on January 12th? *Ans.* 22° in Capricornus; sun slower than clock 7 minutes 6 seconds.

Table of Equation of Time.

Sun faster than Clock in				
Degrees.	Aries. ♈	Taurus. ♉	Gemini. ♊	1st Quar.
	Libra. ♎	Scorpio. ♏	Sagittarius. ♐	3d Quar.
0	0 min. 0 sec.	8 min. 24 sec.	8 min. 46 sec.	30
1	0 " 20 "	8 " 35 "	8 " 36 "	29
2	0 " 40 "	8 " 45 "	8 " 25 "	28
3	1 " 0 "	8 " 54 "	8 " 14 "	27
4	1 " 19 "	9 " 3 "	8 " 1 "	26
5	1 " 39 "	9 " 11 "	7 " 49 "	25
6	1 " 59 "	9 " 18 "	7 " 35 "	24
7	2 " 18 "	9 " 24 "	7 " 21 "	23
8	2 " 37 "	9 " 31 "	7 " 6 "	22
9	2 " 56 "	9 " 36 "	6 " 51 "	21
10	3 " 16 "	9 " 41 "	6 " 35 "	20
11	3 " 34 "	9 " 45 "	6 " 19 "	19
12	3 " 53 "	9 " 49 "	6 " 2 "	18
13	4 " 11 "	9 " 51 "	5 " 45 "	17
14	4 " 29 "	9 " 53 "	5 " 27 "	16
15	4 " 47 "	9 " 54 "	5 " 9 "	15
16	5 " 4 "	9 " 55 "	4 " 50 "	14
17	5 " 21 "	9 " 55 "	4 " 31 "	13
18	5 " 38 "	9 " 54 "	4 " 12 "	12
19	5 " 54 "	9 " 52 "	3 " 52 "	11
20	6 " 10 "	9 " 50 "	3 " 32 "	10
21	6 " 26 "	9 " 47 "	3 " 12 "	9
22	6 " 41 "	9 " 43 "	2 " 51 "	8
23	6 " 35 "	9 " 38 "	2 " 30 "	7
24	7 " 9 "	9 " 33 "	2 " 9 "	6
25	7 " 23 "	9 " 27 "	1 " 48 "	5
26	7 " 36 "	9 " 20 "	1 " 27 "	4
27	7 " 49 "	9 " 13 "	1 " 5 "	3
28	8 " 1 "	9 " 5 "	0 " 43 "	2
29	8 " 13 "	8 " 56 "	0 " 22 "	1
30	8 " 24 "	8 " 46 "	0 " 0 "	0
2d Quar.	Virgo. ♍	Leo. ♌	Cancer. ♋	Degrees.
4th Quar.	Pisces. ♓	Aquarius. ♒	Capricornus. ♑	
Sun slower than Clock in				

PROBLEM XXXIII.

To find the sun's meridian altitude for any given day at any given place.

RULE.—Find the sun's declination for the given day by Problem XIV., and rectify the globe for a corresponding latitude by Problem XV. Find the latitude of the given place by Problem I. The number of degrees on the celestial brazen meridian measured from a degree corresponding with the latitude to the nearest point of the horizon will be the required meridian altitude of the sun.

1. What is the sun's altitude at Vienna on December 22d? *Ans.* 19°.

2. How high is the sun from the horizon at Genoa on February 28th at 12 M.? *Ans.* $27\frac{1}{2}°$.

3. What is the sun's meridian altitude on June 22d at Bermuda Island? *Ans.* 81°.

PROBLEM XXXIV.

To find the sun's amplitude at any given place for any given day.

RULE.—Find the latitude of the given place by Problem I., and rectify the globe for that latitude by Problem XV. Find the sun's place in the ecliptic for the given day by Problem XIV., and bring it on the celestial globe to the eastern edge of the horizon. The number of degrees on the horizon between the sun's place on the ecliptic and the east point on the horizon will be the required amplitude.

1. What is the sun's amplitude at Land's End on August 8th? *Ans.* 23°.

2. At what point of the compass will the sun rise on September 23d at St. Helena? *Ans.* East; amplitude, 0°.

3. At what point of the compass will the sun set on April 22d at Juan Fernandez Island? *Ans.* East by north, 5° north; amplitude, 5°.

To find the sun's azimuth and his amplitude at any given place for any given day and hour.

Rule.—Find the latitude of the given place by Problem I., and rectify the globe to that latitude by Problem XV. Screw the quadrant of altitude to the celestial brazen meridian over the latitude of the given place. Find the sun's place in the ecliptic for the given day by Problem XIV., and bring it, on the celestial globe, to the celestial brazen meridian; then set the hour circle to 12 o'clock. If the given hour be before noon, turn the globe eastward; but if it be after noon, turn it westward as many hours on the hour circle as are equal to the difference between the given hour and noon. Bring the graduated edge of the quadrant of altitude over the sun's place. Then, 1st. The number of degrees from the north or south point of the horizon to the graduated edge of the quadrant of altitude will be the required azimuth. 2d. The number of degrees on the quadrant of altitude from the horizon to the sun's place on the ecliptic will be the required altitude for the given day and hour.

1. What is the sun's altitude and azimuth at Pekin on the 12th of August, at half past 10 A.M.? *Ans.* Azimuth, 72° N.; altitude, 41°.

2. What is the sun's altitude and azimuth on the 28th of June, at half past 4 P.M., at Barbadoes? *Ans.* Azimuth, 68° N.; altitude, 57°.

3. What is the sun's altitude and azimuth at the Mauritius on May 1st at 2 P.M.? *Ans.* Azimuth, 60° N.; altitude, 57°.

PROBLEM XXXV.

The latitude of a place, the day of the month, and the sun's altitude being given, to find the sun's azimuth, and the hour of the day.

RULE.—Rectify the globe for the latitude of the given place by Problem XV., and screw the quadrant of altitude on the celestial brazen meridian over the latitude of the given place. On the celestial globe, find the sun's place in the ecliptic for the given day by Problem XIV., and bring it to the graduated side of the celestial brazen meridian. Set the hour circle to twelve, and turn the globe until the sun's place coincides with the given altitude on the quadrant. The hours passed over by the hour circle give the required time from noon, and the azimuth will be found on the horizon as in Problem XXXIV.

1. At what hour on the 9th of March is the sun's altitude 25° at London, and what is his azimuth, observation being made in the forenoon? *Ans.* 8 hours 48 minutes A.M.; azimuth, 52½° from the south.

2. At what hour of the day at Quebec on the 20th of September is the sun's altitude 21°, and what is his azimuth, observation being made in the morning? *Ans.* 8 hours 30 minutes A.M.; azimuth, 66° south.

3. At what hour at Lisbon is the sun's altitude 30° on the 18th of May, and what is his azimuth, observation being made in the afternoon? *Ans.* 4 hours 30 minutes P.M.; azimuth, 88° from the north.

PROBLEM XXXVI.

The latitude of a place and the day of the month being given, to find at what hour the sun will be due east or west.

Rule.—Rectify the globe for the given latitude by Problem XV. Screw the quadrant of altitude on the celestial brazen meridian over the given latitude, and set the hour circle to twelve. On the celestial globe, find the sun's place in the ecliptic for the given day by Problem XIV., and bring it to the graduated side of the meridian. Bring the lower end of the quadrant of altitude to the east point of the horizon, and hold it in this position while the globe is turned on its axis until the sun's place comes to the graduated side of the quadrant of altitude. The number of hours passed over by the index, subtracted from twelve, will be the required hour when the sun will be due east, and this number added to twelve will be the required hour when the sun will be due west.

1. At what hours will the sun be due east and west at Berlin on June 21st, and what will be his altitude? *Ans.* 7 hours 45 minutes A.M., and 4 hours and 15 minutes P.M.; altitude, 28°.

2. At what hour will the sun be due east and west on May 30th at St. John's, Newfoundland, and what will then be his altitude from the horizon? *Ans.* 7 hours 20 minutes A.M., and 4 hours 40 minutes P.M.; altitude, 25°.

3. At what hours on the 30th of August will the sun be due east and west at Port Philip, Australia, and what will then be his altitude? *Ans.* 5 hours 45 minutes A.M., and 6 hrs. 15 minutes P.M.; altitude, −17°.

PROBLEM XXXVII.

Given the sun's meridian altitude and the day of the month, to find the latitude of the place.

Rule.—Find the sun's declination for the given day by Problem XIV., and if it be south, add to it the sun's altitude, but if north, subtract it. Subtract this sum or difference, as the case may be, from 90°, and the remainder will be the required latitude of the place.

1. What is the latitude of a place where the sun's altitude is 50° on March 30th? *Ans.*

2. What is the latitude of a place where the sun's altitude is 60° on May 20th? *Ans.*

3. What is the latitude of that place where the altitude of the sun is 70° on December 1st? *Ans.*

PROBLEM XXXVIII.

The length of the longest day at any given place not within the polar circles being given, to find the latitude of that place.

Rule.—If the place be north of the equator, bring the first point of the sign Cancer, or if south, of Capricorn, to the graduated side of the celestial brazen meridian, and set the hour circle to twelve. Turn the celestial globe westward until the index has passed over as many hours as equal half the length of the day. Elevate or depress the north pole until the first point of Cancer or Capricorn comes to the horizon. The altitude of the north or south pole will correspond with the latitude.

1. In what degree north latitude is the length of the longest day sixteen hours?

2. In what latitude south does the sun set on the 22d of December at 7 o'clock?

3. In what degree north latitude is the length of the longest day three times the length of the shortest night?

PROBLEM XXXIX.

Given the day of the month, and the sun's amplitude at sunrise, to find the latitude of the place of observation.

RULE.—Find the sun's place in the ecliptic by Problem XIV., and bring it to the horizon. Elevate or depress the north pole until the sun's place coincides with the given amplitude. The altitude of the poles will correspond in degrees with the required latitude.

1. On the 2d of May the sun's amplitude toward the north was 18°. What was the latitude of the place of observation?

2. On the 21st of June the sun's amplitude was observed to be 24° toward the north. What was the latitude of the place of observation?

3. The sun's amplitude on December 2d was observed at sunrise to be 20° toward the south. What was the latitude of the place of observation?

CHAPTER IV.

A CATALOGUE OF THE CONSTELLATIONS AND VISIBLE STARS, TOGETHER WITH THEIR REPRESENTATIONS, LOCATIONS, ETC.

THE stars visible to the naked eye are divided into seven classes or magnitudes, those of the greatest brilliancy being of the first magnitude, those next in brilliancy of the second magnitude, those not quite so bright of the third, and so on; but by the aid of the telescope many others are brought to view, and the gradation is carried on through these to the sixteenth magnitude.

On the globe to which this catalogue is an accompaniment those stars only of the first four magnitudes are laid down.

Since 1603 astronomers denote the various stars in a constellation by the small Greek letters, the brightest being represented by α (Alpha), the next in brilliancy by β (Beta), and so on through the alphabet; and when these are exhausted they have recourse to the small Roman letters, and lastly to the numerals 1, 2, 3, etc.

We here present the small letters of the Greek alphabet for the benefit of those unacquainted with them.

α Alpha.	η Eta.	ν Nu.	τ Tau.
β Beta.	θ Theta.	ξ Xi.	υ Upsilon.
γ Gamma.	ι Iota.	o Omikron.	ϕ Phi.
δ Delta.	κ Kappa.	π Pi.	χ Chi.
ε Epsilon.	λ Lambda.	ρ Rho.	ψ Psi.
ζ Zeta.	μ Mu.	σ Sigma.	ω Omega.

Zodiacal Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Pisces, the Fishes.	Two fishes tied at the extremity of a long ribbon.	N. Andromeda. E. Cetus, Aries, Triangula. S. Aquarius. W. Andromeda, Pegasus.	5°	10° N.	113	α Piscium.	El Rischa.	1st	27½°	N. 2°
						β "	———	4th	342	2½
						γ "	———	"	346	2½
						δ "	———	"	10	6½
						ϵ "	———	"	13	7
						ζ "	———	"	15½	7
						η "	———	"	20	14
Aries, the Ram.	A ram in a recumbent position.	N. Triangula, Musca. E. Taurus. S. Cetus. W. Pisces.	30°	22° N.	66	α Arietis.	Arietis, or El Nath.	2d	29°	N. 22½°
						β "	Sheratan.	3d	26	20
						γ "	Mesarthim.	4th	26½	18½
						δ "	———	"	44	18½
						ϵ "	———	"	41	20
Taurus, the Bull.	A bull, in the attitude of rage, about to plunge at Orion.	N. Perseus, Auriga. E. Gemini. S. Orion, Eridanus. W. Aries.	65°	16° N.	141	α Tauri.	Aldebaran.	1st	66½°	N. 16°
						β "	Aurigæ. [des.	2d	79	28½
						γ "	One of the Hya-	3d	62½	15
						ϵ "	"	"	64	18½
						ζ "	———	"	82	21
						η "	Alcyone, one of the Pleiades.	"	54	23½
						ι "	———	4th	72	22
						κ "	———	"	48	3
						λ "	———	"	57	12½
						μ "	———	"	62	7½
						ν "	———	"	57½	5½
						ξ "	———	"	48½	8
						o "	———	"	49	9

Zodiacal Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Gemini, the Twins.	Twin brothers Castor and Pollux in a sitting posture.	N. {Telescopium, Herschellii. E. Cancer. S. {Canis Minor, Monosceros. W. {Orion, Taurus, Auriga.	111°	33° N.	85	α Geminorum.	Castor.	2d	111°	N. 32°
						β "	Pollux.	"	114	$28\frac{1}{2}$
						γ "	Alhena.	4th	97	$16\frac{1}{2}$
						δ "	Wasat.	3d	107	22
						ϵ "	Melucta.	"	98	25
						ζ "	———	4th	102	21
						η "	Tejat.	"	91	23
						θ "	———	"	95	$34\frac{1}{2}$
						μ "	———	3d	$93\frac{1}{2}$	23
						ν "	———	4th	$94\frac{1}{2}$	21
						o "	———	"	110	$27\frac{1}{2}$
Cancer, the Crab.	A crab.	N. Lynx. E. Leo. S. Hydra. W. {Canis Minor, Gemini.	126°	20° N.	83	α Cancri.	Acubens.	4th	$131\frac{1}{2}$°	N. 13°
						β "	———	3d	121	9
						γ "	Asellus Borealis.	4th	$127\frac{1}{2}$	23
						δ "	" Australis.	"	$127\frac{1}{2}$	18
						ψ "	———	"	119	27
Leo, the Lion.	A lion.	N. {Leo Minor, Ursa Major. E. {Como Berenices, Virgo. S. {Sextans, Crater. W. Cancer.	150°	15° N.	95	α Leonis.	Regulus.	1st	150°	N. 13°
						β "	Denobola.	2d	165	$15\frac{1}{2}$
						γ "	Al Gieba.	3d	153	$20\frac{1}{2}$
						δ "	Zosma.	"	155	$21\frac{1}{2}$
						ϵ "	———	"	142	$24\frac{1}{2}$
						ζ "	Adhafera.	"	151	25
						η "	———	4th	149	17
						θ "	———	3d	166	17
						κ "	———	4th	138	27
						λ "	———	"	139	$23\frac{1}{2}$
						μ "	Ras al Asad.	3d	147	$27\frac{1}{2}$
						ξ "	———	4th	$138\frac{1}{2}$	13
						o "	———	"	143	11

Virgo, the Virgin.	A winged female holding an ear of corn in her hand.	N. Como Berenices, Bootes. E. Libra. S. Noctua, Corvus, Crater. W. Leo.	195°	5° N.	110	α Virginis.	Spica Virginis.	1st	199°	S. 10°
						β "	Zavijava.	3d	173½	N. 2½
						γ "	———	"	188½	S. 0½
						δ "	———	"	192	N. 4
						ε "	Vindemiatrix.	"	193	12
						ζ "	———	"	201	1½
						η "	———	"	182	2
						θ "	———	4th	193½	S. 5
						κ "	———	"	210	9
						λ "	———	"	211	12½
						μ "	———	"	217½	5
						Z "	———	"	219½	N. 3
						C "	———	"	183	5
						φ "	———	"	214	S. 2
Libra, the Balance.	A pair of scales.	N. Serpens, Virgo. E. Scorpio. S. Noctua, Lupus. W. Virgo.	226°	8° S.	51	α Libræ.	Zubeneschmali.	2d	220°	S. 15½°
						β "	Zubenelgenabi.	"	227	9
						γ "	———	3d	230	14
						ε "	———	4th	228½	10
						ζ "	———	"	230½	17
						η "	———	"	234	15
						ι "	———	3d	225½	19
						κ "	———	4th	231	19
						λ "	———	"	235½	19½
						ξ "	Zubenhakrabi.	"	236	11
Scorpio, the Scorpion.	A scorpion.	N. Serpentarius. E. Sagittarius. S. Ara, Lupus. W. Libra.	244°	26° S.	44	α Scorpii.	Antares.	1st	245°	S. 26°
						β "	Graffias.	2d	230	19
						ε "	———	3d	248	34½
						ζ "	———	"	248	42
						η "	———	"	253½	43
						θ "	———	"	260	43
						ι "	———	"	263	40
						κ "	———	"	261½	38
						λ "	Lesuth.	"	260	36½
						μ^1 "	———	"	248	38
						μ^2 "	———	4th	249	37½
						τ "	———	3d	246	27½
						d "	———	4th	231	28
						o "	———	"	231½	29
						π "	———	3d	235	26

Zodiacal Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Sagittarius, the Archer.	A centaur, with drawn bow and arrow in hand, and quiver on his shoulder.	N. Scutum Sobieskii, Antinous. E. Capricornus. S. Telescopium. W. Scorpio, Corona Australis.	285°	33° S.	69	β Sagittarii.	———	4th	271°	S. 37°
						δ "	———	3d	274	30
						ϵ "	———	2d	273	35
						λ "	———	4th	274	25½
						μ^1 "	———	"	270½	22
						μ^2 "	———	"	270½	21
						o "	———	"	283	22
						π "	———	"	284	21½
						σ "	———	3d	280	27
						τ "	———	4th	283½	27½
						ψ "	———	"	285	26
						χ "	———	3d	268	31
						ζ "	———	4th	282	30½
Capricornus, the Goat.	A goat with a tail like that of a fish.	N. Antinous. E. Aquarius. S. Piscis Australis. W. Sagittarius.	310°	20° S.	51	α Capricorni.	Giedi.	3d	302°	S. 13°
						β "	———	"	303	15
						γ "	Deneb Algedi.	4th	321	18
						ϵ "	———	"	320	24
						κ "	———	"	320½	21
						λ "	———	"	324	12½
						ν "	Dabih.	"	302½	13½
						σ "	Sad Naschirah.	3d	324	18
Aquarius, the Waterbearer.	A man pouring water out of an urn.	N. Pegasus, Equuleus. E. Capricornus, Antinous. S. Piscis Australis. W. Piscis Occidentalis, Cetus.	335°	14° S.	108	α Aquarii.	Sad El Melik.	3d	228½°	S. 1°
						β "	Sad Es Saud.	"	320½	6½
						δ "	Scheat.	"	341	17
						ζ "	———	4th	334	1
						η "	———	"	336	1½
						θ "	Ancha.	"	331	8½
						λ "	———	"	340	8½
						π "	———	"	333½	N. 1
						ϕ "	———	"	346	S. 7
						χ "	———	3d	333	2
						c "	———	4th	344	22½

Northern Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Andromeda.	A woman with extended arms, her wrists and ankles bound with chains.	N. Cassiopeia. E. Perseus, Triangula. S. Pisces, Pegasus. W. Gloria Fredericæ, Lacerta.	14°	30° N.	66	α Andromedæ.	Alpheratz.	2d	0°	N. 28°
						β "	Merach.	"	15	35
						γ "	Almaach.	"	28½	41½
						δ "	Delta.	3d	7½	30
						ε "	———	4th	7½	28
						ζ "	———	"	9	23½
						μ "	———	3d	11	37
						ν "	———	4th	10	38½
						ο "	———	"	26	48½
						π "	———	"	7	33
Auriga, the Wagoner.	A man with one foot resting on a horn of Taurus, holding a goat and kids in one hand, and a bridle in the other.	N. Camelopardalis. E. Lynx, Telescopium, Gemini. S. Taurus. W. Perseus.	75°	45° N.	66	α Aurigæ.	Capella.	1st	76°	N. 46°
						β "	Menkalina.	2d	86½	45
						δ "	———	4th	86	52
						ε "	The Kids.	"	72	43½
						ζ "	———	"	71	40
						η "	———	"	72½	41
						θ "	———	"	86½	37
						ι "	———	"	69½	32½
						κ "	———	"	76	39
Aquila et Antinous, the Eagle and Antinous.	An eagle, and a boy with bow and arrows in extended hand.	N. Anser et Vulpecula. E. Delphinous. S. Scutum Sobieskii, Sagittarius, Capricornus. W. Cerberus, Taurus Poniatowski.	295°	8° N.	71	α Aquilæ.	Altair.	1st	293½°	N. 8½°
						β "	Alshain.	3d	296½	6
						γ "	Tarazed.	"	294½	10
						δ "	———	"	289	3
						ε "	———	4th	282	14
						ζ "	———	"	284½	13
						η "	———	3d	296	½
						θ "	———	"	300	S. 2
						μ "	———	4th	290½	N. 7
						λ "	———	3d	283	S. 6½

Northern Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Anser et Vulpecula, the Fox and Goose.	A fox carrying a goose in his mouth.	N. Cygnus. E. Pegasus. S. Sagitta. W. Cerberus.	300°	25° N.	35	α Vulpeculæ. b " i "	——— ——— ———	3d 4th "	294° 290 305	N. 27° 24 29
Bootes, the Bear-driver.	A huntsman in a running posture, holding a club in one hand, and in the other the leash of two greyhounds, Asterion and Chara.	N. Draco. E. Herculis, Corona Borealis, Serpens. S. Virgo. W. Como Berenices, Canes Venatici, Ursa Major.	212°	20° N.	54	α Bootis. β " γ " δ " ε " ζ " η " μ " λ " ξ " π " τ " υ "	Arcturus. Nekkar. Seginas. ——— Mirac. ——— Muphride. Alkaturops. ——— ——— ——— ——— ———	1st 3d " 4th 3d " " 4th " " " " "	212° 224 216 227 219½ 218 207 229 212 221 218 205 205	N. 20° 41 39½ 34 28 14½ 19 37½ 47½ 20 17½ 18 16½
Camelopardalus, the Giraffe.	A giraffe.	N. Ursa Minor. E. Draco, Ursa Major. S. Lynx, Bootes. W. Perseus, Cassiopeia.	68°	70° N.	36	B Camelopar- C " [dali. D " c " d′ " K " P "	——— ——— ——— ——— ——— ——— ———	4th " " " " " "	48° 48½ 48 67½ 71 74 97½	N. 59° 58 54½ 66 61 78½ 67½
Canes Venatici, the Greyhounds.	Two dogs, Asterion and Chara.	N. Ursa Major. E. Bootes. S. Como Berenices. W. Ursa Major.	200°	40° N.	15	α Cor. Caroli.	———	3d	190°	N. 40°

Cassiopeia.	A female seated in a chair.	N. Cepheus. E. Camelopardalus, Perseus. S. Andromeda. W. Cepheus, Gloria Frederica.	12°	60° N.	55	α Cassiopeiæ.	Schedir.	3d	8½°	N. 65½°
						β "	Caph.	"	0	58
						γ "	———	"	12	60
						δ "	Ruchbah.	"	18	59
						ε "	———	4th	5	52
						ε′ "	———	"	25	62
						η "	———	"	7½	57
						θ "	———	"	25	53
						χ "	———	"	4	61½
						χ′ "	———	"	3	62½
Cepheus.	A king in royal robes, with sceptre in hand.	N. Ursa Minor. E. Cassiopeia. S. Lacerta, Cygnus. W. Draco.	338°	68° N.	35	α Cephei.	Alderamin.	3d	319°	N. 62°
						β "	Alphirk.	"	321	69½
						γ "	Er Rai.	"	353	77
						δ "	Var.	4th	336	57½
						η "	———	"	306	61½
Como Berenices, Berenices' Hair.	The flowing tresses of a lady's hair.	N. Canes Venatici. E. Bootes. S. Virgo. W. Leo Minor.	185°	26° N.	20	h Como Berenices.	———	4th	186°	N. 24°
						q "	———	4th	190½	22½
Corona Borealis, Northern Crown.	A crown.	N. Hercules. E. Hercules. S. Serpentarius. W. Bootes.	235°	30° N.	21	α Coronæ Borealis.	Alphacca.	2d	232°	N. 27°
						β "	———	4th	230	29
						γ "	———	"	234	27
						δ "	———	"	236	26½
						ζ "	———	"	234	37
						π "	———	"	238	23½
						σ "	———	"	227	34
Cygnus, the Swan.	A swan, on outspread wings, flying toward the southwest.	N. Cepheus. E. Lacerta, Pegasus. S. Vulpecula. W. Lyra, Draco.	303°	42° N.	81	α Cygni.	Deneb.	2d	308½°	N. 45°
						β "	Albiero.	3d	291	27½
						γ "	Sadr.	"	304	39
						δ "	———	"	295	45
						ζ "	———	"	316	29½
						θ "	———	4th	291½	50
						ξ "	———	"	314	43½
						ο "	———	"	318½	39½
						π "	———	"	318	37½
						σ "	———	"	323	28
						τ "	———			

Northern Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Delphinus, the Dolphin.	The dolphin fish.	N. Vulpecula. E. Pegasus. S. Antinous. W. Aquila.	303°	15° N.	18	α Delphini.	———	3d	308°	N. 15°
						β "	———	"	307½	14
						γ "	———	"	310	15½
						δ "	———	"	307	15
						ϵ "	———	"	306	10
Draco, the Dragon.	A sea monster, resembling a serpent, with six coils in its body.	N. {Ursa Major, Cepheus. E. {Cepheus, Cygnus. S. {Hercules, Quadrans, Bootes. W. Camelopardalus.	270°	66° N.	80	α Draconis.	Thuban.	3d	210°	N. 65°
						β "	Rastaban.	2d	261½	52½
						γ "	Etanin.	"	268	51½
						δ "	———	4th	239	67½
						ϵ "	———	"	297	70
						ζ "	———	3d	258	66
						η "	———	4th	245	62
						θ "	———	"	239	58
						κ "	———	"	276	71½
						λ "	Giamsar.	"	166	71
						χ "	———	"	165	72
						ο "	———	"	292½	68½
						π "	———	"	290	65½
						ρ "	———	"	282	59
						σ "	———	"	288	62
						a "	———	"	247½	69
						b "	———	"	230	59
						K "	———	"	287	53
						m "	———	"	262½	55½
						n "	El Rakis.	"	256½	54
Equuleus, the Horse's Head.	A horse's head.	N. Delphinous. E. Pegasus. S. Aquarius. W. Aquila.	316°	5° N.	10	α Equuleii.	Kitel Phard.	4th	316°	N. 4½°
						β "	———	"	318	6
						γ "	———	"	316½	8½
						δ "	———	"	315½	9½

Hercules.	A man invested with the skin of the Nemean lion, holding a club in his right hand, and the three-headed dog Cerberus in his left.	N. Draco. E. {Lyra, Aquila. S. Serpentarius. W. {Serpentarius, Corona Borealis, Bootes.	255°	22° N.	113	α Herculis.	Ras Algethi.	3d	257°	N. 14½°
						β "	Rutilicus.	"	246	22
						γ "	——	"	243½	19½
						δ "	——	"	257	25
						ϵ "	——	"	252	21½
						ζ "	——	"	249	32
						η "	——	"	249	39
						θ "	——	"	267	37½
						λ "	——	4th	260	27
						λ' "	——	"	270	28½
						μ "	——	"	264½	27½
						ν "	——	"	259	25
						ξ "	——	"	267½	29
						π "	——	"	257	37½
						ρ "	——	"	261	37½
						σ "	——	"	247	42½
						τ "	——	"	243	47
						C "	——	"	270	21
						D "	——	"	268	22½
						E "	——	"	267	15
						F "	——	"	275	22
						M "	——	"	279	17½
Lacerta, the Lizard.	A lizard.	N. Cepheus. E. {Gloria Frederica. S. Pegasus. W. Cygnus.	337°	42° N.	6	β Lacerti.	——	4th	334°	N. 49°
Leo Minor, the Lesser Lion.	A lion in a recumbent posture.	N. Ursa Major. E. {Ursa Major, Como Berenicis. S. Leo Major. W. Lynx.	150°	35° N.	53	1 {Leonis Minoris.}	——	3d	157°	N. 33°
Lynx.	A lynx.	N. Camelopardalus. E. {Ursa Major, Leo Minor. S. {Cancer, Gemini. W. Auriga.	111°	50° N.	44	b Lyncis.	——	4th	90°	N. 59°
						c "	——	"	138	36
						d "	——	"	136	38

Northern Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Lyra, the Harp.	A harp.	N. Draco. E. Cygnus. S. Cerberus. W. Hercules.	283°	38° N.	21	α Lyræ.	Vega.	1st	278°	N. 38½°
						β "	———	2d	281	33
						γ "	———	"	284	32½
						δ "	———	4th	283	37
Musca, the Fly.	A fly.	N. Caput Medusæ. E. Perseus. S. Aries. W. Triangula.	40°	28° N.	6	α Muscæ.	———	4th	37½°	N. 27½°
						γ ———	———	1st	38	27
						b ———	———	4th	37½	28
Medusæ Caput, Head of Medusa.	The head of Medusa, with snakes for hair.	N. Perseus. E. Perseus. S. Musca. W. Andromeda.	43°	37° N.	6	α Medusæ.	———	4th	41°	N. 37½°
						β "	Algol.	3d	41	40
						τ "	———	4th	40	38
						P "	———	"	38	37
Perseus.	A man with sword in his right hand, the head of Medusa in his left, with wings at his feet.	N. Camelopardalus. E. Auriga. S. Musca. W. Andromeda.	6°	49° N.	59	α Persei.	Algenib.	2d	48°	N. 49°
						γ "	———	"	44	53
						δ "	———	3d	53	47
						ε "	———	"	57	39½
						ζ "	———	"	56	31
						η "	———	4th	40	55
						θ "	———	"	37½	48
						λ "	———	"	57	50
						μ "	———	"	60	47½
						ν "	———	"	52½	42
						ψ "	———	3d	51	47
Pegasus, the Flying Horse.	A winged horse in an inverted position.	N. Lacerta, Andromeda. E. Pisces. S. Pisces, Aquarius. W. Equuleus, Delphinus, Vulpecula.	340°	14° N.	89	α Pegasi.	Markab.	2d	344°	N. 14½°
						β "	Scheat.	"	344	27
						γ "	Algenib.	"	1	14
						ε "	Enif.	3d	324	9
						ζ "	———	"	338	10
						η "	———	"	339	29
						θ "	———	4th	330	5½
						κ "	———	"	325	25
						i "	———	"	329	25
						λ "	———	"	341	23
						μ "	———	"	342	24
						π "	———	"	330	33

Serpentarius or Ophiuchus, the Serpent-bearer.	A man with a venerable beard, having both hands clasped in the folds of a serpent writhing in his grasp.	N. Hercules. E. Taurus Poniatowskii, Scutum Sobieskii. S. Scorpio. W. Libra, Bootes.	260°	10° S.	74	α Serpentarii. β “ γ “ δ “ ε “ ζ “ η “ θ “ ι “ κ “ λ “ μ “ ν “ ξ “ φ “ ρ “ B “	Ras Alhague. Cheleb. —— Yed. —— —— —— —— —— —— Marsic. —— —— —— —— —— ——	2d 3d “ “ “ “ “ “ 4th “ “ “ “ “ “ 3d 4th	262° 265 265½ 241 235½ 246 255 257 250 251 244½ 259½ 257 261½ 244½ 257 258½	N. 13° 4½ 3 S. 3 4 10½ 15½ 21½ N. 11 9½ 3 S. 8½ 12½ 15½ 16½ 25 23½
Serpens, the Serpent.	A large serpent held in the hands of Ophiuchus.	N. Corona Borealis, Hercules, Ophiuchus, Taurus Poniatowskii. E. Antinous, Scutum Sobieskii. S. Libra, Scorpio, Sagittarius. W. Bootes, Virgo.	255°	5° N.	64	α Serpentis. β “ γ “ δ “ ε “ ζ “ η “ θ “	Unuk. —— —— —— —— —— —— ——	2d 3d “ “ “ 4th 3d “	233½° 234 236 231½ 235 267 272½ 282	N. 5½° 16½ 16½ 12 5½ S. 4½ 3 N. 3½
Sagitta, the Arrow.	An arrow.	N. Vulpecula. E. Vulpecula. S. Aquila. W. Aquila.	296°	18° N.	18	α Sagittæ. β “	—— ——	4th “	293° 297	N. 17½° 18½

Northern Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Scutum Sobieskii.	A shield with a cross on it.	N. Serpens. E. Antinous. S. Sagittarius. W. Serpens.	277°	10° S.	8	None.				
Triangula, the Triangles.	Two triangles, one over the other.	N. Andromeda. E. Musca. S. Aries. W. Delphinus.	22°	27° N.	16	α Triangulorum. β "	—— ——	4th "	24° 30	N. 28° 34
Taurus Poniatowskii, the Bull of Poniatowski.	A small bull.	N. Cerberus. E. Antinous. Aquila. S. Serpens. W. Ophiuchus.	275°	7° N.	7	h Taurus Poniatowskii. k " P "	—— —— ——	4th " "	267½° 267½ 268½	N. 3° 1½ 2½
Ursa Major, the Greater Bear.	A large bear.	N. Draco, Camelopardalus. E. Bootes, Canes Venatici. S. Leo Minor. W. Lynx, Camelopardalus.	153°	60° N.	87	α Ursa Majoris. β " γ " δ " ε " ζ " η " θ " ι " λ " μ " ν " ξ " ο " υ " ψ " χ "	Dubhe. Merak. Phad. Megres. Alioth. Mizar. Benetnasch. —— Al Kaprah. —— El Phekrah. —— El Acola. —— —— —— ——	2d " " 3d 2d 3d 2d 4th " " 3d 4th " " " " "	163° 163 176 182 190 199 205 140 132 174 153 166½ 166½ 122 144 164 131	N. 62½° 57 54½ 58 57½ 56 50 51 48½ 49 42½ 34½ 32½ 61½ 61 46 48

Ursa Minor, the Little Bear.	A small bear.	N. ——. E. Cepheus. S. Draco. W. Camelopardalus. Draco.	235°	75° N.	24	α Ursa Minoris. β “ γ “ δ “ ϵ “ ζ “ Λ “	Polaris. Kochab. Guards. —— —— —— ——	2d 3d 4th “ “ “ “	15° 221 232 271 256 240 217½	N. 88½° 74½ 86 86½ 78 78½ 77

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Ara, the Altar.	An altar with a burning sacrifice.	N. Scorpio. E. Telescopium. S. {Pavo, Triangulæ. W. Circinus.	255°	55° S.	9	α Aræ.	———	3d	258½°	S. 49°
						β "	———	"	258	55
						γ "	———	"	257½	56½
						δ "	———	4th	259	60½
						ε "	———	"	250	52½
						ζ "	———	"	250½	55½
						θ "	———	"	267½	50
Apus, the Bird of Paradise.	A bird of Paradise.	N. Triangulæ. E. Pavo. S. Chamæleon. W. {Apus Indica, Robur Caroli.	252°	75° S.	11	None.				
Argo Navis, the Ship Argo.	A ship.	N. {Monoceros, Hydra. E. Robur Caroli. S. {Pisces Volans, Equules Pictoris. W. Canis Major.	115°	50° S.	64	α Argo Navis.	Canopis.	1st	95°	S. 53°
						γ "	———	2d	118	46½
						ε "	———	"	125	58
						ζ "	Naos.	"	119	39½
						κ "	Markeb.	4th	115½	24½
						λ "	———	"	119½	24
						ξ "	Asmidiske.	"	116½	22
						χ "	———	2d	138½	58½
Sceptrum Brandenburgium, the Sceptre of Brandenburg	A sceptre.	N. Eridanus. E. Lepus. S. Eridanus. W. Eridanus.	67°	16° S.	6	m {Sc. Brandenborgii.}	———	3d	68°	S. 21°
						n "	———	4th	66	8
						p "	———	"	67	15
Canis Major, the Greater Dog.	A dog in the upright posture.	N. Monoceros. E. Argo Navis. S. Argo Navis. W. Lepus.	105°	20° S.		α Canis Major.	Sirius.	1st	99°	S. 16½°
						β "	Mirzam.	3d	94	18
						γ "	———	"	108	36½
						δ "	Wesen.	"	104	24
						ε "	Adhara.	"	102½	28
						ζ "	———	"	94	30
						η "	Aludra.	"	108½	28½
						θ "	———	4th	101	13½
						ι "	———	"	102	26½
						κ "	———	"	101½	16½
						λ "	———	"	94	33½

Canis Minor, the Lesser Dog.	A little dog.	N. Gemini. E. Cancer, Hydra. S. Monoceros. W. Monoceros.	142°	5° N.	14	α Canis Minoris. β " γ "	Procyon. Gomelza. ——	1st 3d 4th	113° 109½ 117½	N. 5½° 8½ 2½
Centaurus, the Centaur.	A figure of a man terminating in the body of a horse, transfixing the body of a wolf with a spear which he holds in one hand.	N. Hydra. E. Lupus. S. Crux, Circinus. W. Argo Navis.	200°	50° S.	35	α Centauri. β " γ " δ " ε " ζ " η " θ " ι " κ " μ " ν "	—— —— —— —— —— —— —— —— —— —— —— ——	3d " " " " " " " " " 4th "	217° 221 187½ 179½ 201 206½ 215 208 197 220 203 204	S. 47° 42½ 47½ 49 52 47 42 36 36 42 41½ 41
Cetus, the Whale.	A large sea monster, with two feet in front. The body behind resembles that of a fish.	N. Aries, Pisces. E. Eridanus. S. Phœnix. W. Fluvius Aquarius.	25°	12° S.	97	α Ceti. β " γ " δ " ε " ζ " η " θ " ι " κ " λ " μ " ξ " ο " π " ρ " σ " τ " υ " χ "	Menkar. Deneb Kaitos. —— —— —— Baten Kaitos. —— —— Schemati. —— —— —— —— Mira. —— —— —— —— —— ——	2d 3d " " " " " " " 4th " " " 3d " 4th " " " "	41½° 9½ 38 37 37 26 14½ 19 2 36 41 38 33½ 31½ 36½ 33½ 36 23 26½ 27	N. 3½° S. 19 N. 2 S. 1 12 11½ 11 9 9½ N. 5 8½ 9 7½ S. 3½ 14½ 13 16½ 17½ 23½ 21

Southern Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Chamæleon.	A chameleon.	N. {Robur Caroli, Musca Indica, Apus. E. Apus. S. Octans. W. Dorado.	175°	78° S.	10	None.				
Columba Noachi, Noah's Dove.	A dove with an olive leaf in her mouth.	N. Lepus. E. Canis Major. S. Equuleus Picto- W. Eridanus. [ria.	85°	35° S.	10	α Columbæ. β " γ " ε "	Phael. ——— ——— ———	2d 3d 4th "	82½° 86½ 87 81	S. 34° 36 35½ 35½
Circinus, the Compasses.	A pair of compasses.	N. Lupus. E. Ara. S. {Triangulum, Australis. W. Centaur.	231°	60° S.	7	None.				
Corvus, the Crow.	A crow.	N. Virgo. E. Noctua. S. Hydra. W. Crater.	185°	15° S.	9	α Corvi. β " γ " δ " ε "	Al Chiba. ——— ——— Algorab. ———	4th 3d " " 4th	179° 186½ 181 184½ 179½	S. 23½° 22½ 16 15½ 21½
Corona Australis, the Southern Crown.	A wreath of evergreens.	N. Sagittarius. E. Sagittarius. S. Telescopium, W. Scorpio.	280°	41° S.	12	None.				
Crater, the Cup.	A cup resting upon Hydra.	N. Leo. E. Corvus. S. Hydra. W. {Hydra, Sextans.	168°	15° S.	31	α Crateris. β " γ " δ " ε " θ " φ "	Alkes. ——— ——— ——— ——— ——— ———	4th " " " " " "	161° 165 168 167 169½ 171½ 166½	S. 17½° 22 16½ 14 9½ 8 2½

Crux, the Cross.	A cross.	N. Centaur. E. Centaur. S. Musca Indica. W. Centaur.	185°	60° S.	6	α Crucis. β “ γ “ δ “ ε “	Acrux. ——— ——— ——— ———	1st 2d “ 3d 4th	184½° 187½ 185 181 182½	S. 62° 58 55 57½ 58½
Dorado, the Sword-fish.	A sword-fish.	N. {Equuleus Pictoria. E. Piscis Volans. S. {Hydrus, Solarium. W. Horologium.	75°	62° S.	6	None.				
Equuleus Pictoria, the Painter's Easel.	A painter's easel.	N. Columba Noachi. E. Argo Navis. S. Dorado. W. Dorado.	85°	52° S.	8	None.				
Eridanus, the River Po.	A river.	N. {Taurus, Psalterium Georgii. E. {Orion, Lepus, Columba Noachi. S. {Horologium, Dorado. W. Cetus.	60°	25° S.	84	α Eridani. β “ γ “ δ “ ε “ ζ “ η “ θ “ ι “ λ “ μ “ ν “ ξ “ ο “ π “ ρ “ σ “ τ “ υ “ φ “ χ “ ψ “ ω “	Fornacis. ———	3d 1st 2d 3d 4th 3d 4th 3d 4th “ “ “ “ “ “ “ “ “ “ “ “ “ “	47° 76 56 52½ 51 46 53 42 38 75 69 66 63 60 48½ 52 54 56 66 63 56 56 48	S. 29° 8 14 11 10½ 9 12½ 42 41 8½ 3½ 2½ 5 7½ 22½ 22½ 23½ 25 30 35 37 38 44

Southern Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Grus, the Crane.	A crane.	N. Piscis Australis. E. Phœnix. S. Toucana. W. Centaur.	330°	45° N.	13	α Grus. β " γ " δ "	——— ——— ——— ———	3d " " "	329° 337 325 334	S. 47½° 48 38½ 45
Horologium, the Clock.	A clock.	N. Cetus. E. Solarium. S. Hydrus. W. Phœnix.	43°	48° S.	12	None.				
Hydra, the Water-serpent.	A water-serpent.	N. Sextans, Crater, Noctua, Corvus. E. Libra. S. Centaur. W. Monoceros, Canis Minor.	189°	15° S.	60	α Hydræ. β " γ " π " τ " φ " δ " ε " ζ "	Alphard. ——— ——— ——— ——— ——— ——— ——— ———	2d 4th 3d 4th " " " " "	140° 175 198 208 142 154 126 127½ 130	S. 7½° 33 22½ 26 ½ 15 N. 6 7 6
Hydrus, the Water-snake.	A snake.	N. Horologium, Solarium. E. Dorado, Chamæleon. S. Octans. W. Toucana.	28°	66° S.	10	α Hydri. β " γ " δ "	——— ——— ——— ———	3d " " 4th	26° 10 55 55	S. 63° 78 75 65
Lepus, the Hare.	A hare.	N. Orion. E. Canis Major. S. Columba Noachi. W. Sceptrum Brandenburgium.	80°	18° S.	19	α Leporis. β " γ " δ " ε " ζ " η " θ " λ " μ "	Arneb. Nebal. ——— ——— ——— ——— ——— ——— ——— ———	3d " " " 4th " " " " "	81° 80 83½ 86 74 83 85½ 87 77 76	S. 17½° 21 23 21 22½ 14 14 15 13 16½

Lupus, the Wolf.	A wolf.	N. Scorpio. E. Scorpio. S. Circinus. W. Centaur.	230°	45° S.	24	α Lupi. ε " ζ " η " λ " ο "	—— —— —— —— —— ——	3d 4th " " 3d 4th	217½° 227 225 236 230 226	S. 47° 43 51 38 40 39½
Musca Indica, the Indian Fly.	A fly.	N. Crux. E. {Apus, {Triangulum. S. Apus. W. Robur Caroli.	185°	69° S.	4	α {Muscæ {Indicæ. β " γ " δ "	—— —— —— ——	4th " " "	180° 188 184 192	S. 67½° 67 71 70
Monoceros, the Unicorn.	A unicorn.	N. {Gemini, {Canis Minor, {Hydra. E. Hydra. S. {Canis Major, {Argo Navis. W. Orion.	110°	0°	31	a Monoceron. b " f " h " k " m "	—— —— —— —— —— ——	4th " " " " "	123½° 93 95 97½ 99 128	S. 31° N. 4 7½ 10 3 S. 7
Orion.	A man assaulting the bull, a club in one hand, and for a shield the skin of a lion in the other.	N. Taurus. E. Monoceros. S. Lepus. W. {Taurus, {Eridanus.	80°	0°	78	α Orionis. γ " δ " ε " ζ " κ " λ "	Betelgeuse. Bellatrix. Mintaka. Anilam. Alnitak. Saiph. Meissa.	1st 2d " " " 3d 4th	85½° 78½ 80 81 82½ 84 80	N. 7° 6½ S. 1½ 2 2½ 9½ N. 10
Phœnix.	A bird rising from amid flames.	N. Cetus. E. {Horologium, {Eridanus. S. {Toucana, {Hydrus. W. Grus.	10°	50° S.	13	α Phœnicis. β " γ " δ " ε " ζ " η " θ "	—— —— —— —— —— —— —— ——	2d 4th 3d 4th " " " "	4° 15 20 6 0 14 21 25	S. 43½° 47½ 44 44 46 47½ 50 52½

Southern Constellations.

Name of Constellation.	Representation.	Boundaries.	Location. R. A.	Location. Dec.	Visible Stars.	Stars on Globe.	Name.	Magnitude.	Location of Stars. R. A.	Location of Stars. Dec.
Piscis Australis, the Southern Fish.	A fish.	N. Aquarius. E. Cetus. S. Grus. W. Capricornus.	335°	30° S.	16	α Piscis Aust. β " γ " δ " ϵ " ζ "	Pham al Haut. —— —— —— —— ——	1st 3d 4th " " "	343° 335 324 323½ 337 327	S. 30½° 33 32 34 28 34½
Pavo, the Peacock.	A peacock.	N. Centaur. E. Toucana. S. Octans. W. {Ara, Triangulum.	302°	68° S.	14	α Pavonis. β " γ " δ " ϵ " ζ "	—— —— —— —— —— ——	2d 4th 3d " 4th "	302° 310 316½ 307 295 275	S. 57° 59 67 67 67 71
Robur Caroli, Charles' Oak.	An oak-tree.	N. Hydra. E. {Centaur, Musca Indica. S. Chamæleon. W. Piscis Volans.	150°	65° S.	12	β {Roboris Caroli.}	——	1st	140°	N. 68°
Quadrans Hadleianus, Hadley's Octant.	A quadrant.	Around and over the South Pole.	310°	80° S.	43	None.				
Telescopium, the Telescope.	A telescope.	N. Centaur. E. Grus. S. Pavo. W. Ara.	275°	52° S.	9	None.				
Triangulum.	A triangle.	N. {Ara, Circinus. E. Pavo, S. Apus. W. Musca Indica.	238°	65° S.	5	α Trianguli. β " γ "	—— —— ——	2d " "	248° 232 225	S. 68° 62½ 67½

CHAPTER IV.

PROBLEMS PERFORMED BY MEANS OF THE CELESTIAL GLOBE.

PROBLEM XL.

To find the right ascension and declination of a heavenly body.

RULE.—Bring the heavenly body under the graduated side of the celestial brazen meridian, on which will be found the declination. The number of degrees on the equinoctial between the meridian and the first degree of the sign Aries will be the right ascension.

1. What is the right ascension and declination of Algenib in Pegasus? *Ans.* R. A., 1°; declination, 14° N.

2. What is the right ascension and declination of Almak in Andromeda? *Ans.* 28½° R. A.; 41° declination N.

3. What is the right ascension and declination of Mira in Cetus? *Ans.* R. A., 32½°; declination, 4° S.

4. What is the right ascension and declination of Antares in Scorpio? *Ans.* R. A., 245°; declination, 26° S.

PROBLEM XLI.

To find the latitude and longitude of a heavenly body.

RULE.—Screw the quadrant of altitude to the celestial brazen meridian over that ecliptical pole which is in the same hemisphere with the heavenly body. Move

the lower end of the quadrant until the heavenly body comes to its graduated edge, on which will be found the required latitude. The number of degrees on the ecliptic reckoned from the first degree of the sign Aries to the graduated edge of the quadrant of altitude will be the required longitude.

1. What is the latitude and longitude of α Scheder in Cassiopeia? *Ans.* Latitude, 61°; longitude, 44°.

2. What is the latitude and longitude of γ Bellatrix in Orion? *Ans.* Latitude, 5° N.; longitude, 74°.

3. What is the latitude and longitude of β Mirach in Andromeda? *Ans.* Latitude, 37°; longitude, 29°.

4. What is the latitude and longitude of β Pollux in Gemini? *Ans.* Latitude, 31°; longitude, 115°.

PROBLEM XLII.

The right ascension and declination of a heavenly body being given, to find its place on the globe.

RULE.—Bring the given degree of right ascension to the graduated edge of the celestial brazen meridian, and under the given declination on it will be found the required heavenly body.

1. What star has right ascension 11° 11′, and declination 59° 38′ N.? *Ans.* γ in Cassiopeia.

2. What star has right ascension 86° 13′, and declination 44° 55′ N.? *Ans.* Menkalina in Auriga.

3. What star has right ascension 113° 16′, and declination 28° 30′ N.? *Ans.* Pollux in Gemini.

4. What star has right ascension 48°, and declination 49° N.? *Ans.* Algenib in Perseus.

PROBLEM XLIII.

The latitude and longitude of a heavenly body being given, to find its place on the globe.

RULE.—Screw the quadrant of altitude to the celestial brazen meridian over that ecliptical pole which is in the same hemisphere with the required heavenly body, and bring that part of the graduated edge of the quadrant marked 0° to the required longitude on the ecliptic. The required heavenly body will be found under the given latitude on the quadrant.

1. What heavenly body has latitude 12° N., and longitude 8°? *Ans.* Algenib in Pegasus.

2. What star has latitude 10° 4′ N., and longitude 107° 21′? *Ans.* Castor in Gemini.

3. What star has latitude 22° 52′ N., and longitude 78° 57′? *Ans.* Capella in Auriga.

4. What star has latitude 21° 6′, and longitude 330° 56′? *Ans.* Enif in Pegasus.

PROBLEM XLIV.

The day and hour, and the latitude of a place being given, to find what stars are rising, setting, culminating, etc.

RULE.—Rectify the globe for the given latitude by Problem XV. Find the sun's place in the ecliptic for the given day by Problem XIV., and bring it on the celestial globe to the graduated edge of the celestial brazen meridian. Set the hour circle to twelve; if the given hour be before noon, turn the celestial globe eastward, but if past noon, westward on its axis until the index has passed over as many hours as the difference between the given hour and noon.

Then all heavenly bodies at the eastern half of the horizon will be rising, those at the western half setting, and those under the celestial brazen meridian will have culminated. All bodies above the horizon will be visible, and those under it invisible.

If the globe be revolved on its axis, those stars which will not sink below the horizon are within the circle of perpetual apparition; those which will not rise above the horizon are within the circle of perpetual occultation. These circles surround the celestial poles, and have radii equal in degrees to the latitude of the given place.

1. At 9 o'clock in the evening of August 12th at New York, what stars will be rising, what stars will be setting, and what stars will be culminating? *Ans.* Rising, Capella in Auriga; culminating, Salaphat in Lyra; setting, Deneb in Leo Major.

2. What stars do not set to the inhabitants of Van Couver's Island? *Ans.* Those north of 60° N. Dec., or those in the northern part of Hydra, Cepheus, Cassiopeia, Camelopardalus, Ursa Major, and all in Ursa Minor.

3. What stars do not rise to the inhabitants of the Madeira Islands? *Ans.* All south of 60° S. Dec., such as those in Pava, Toucan, Hydrus, Piscis volans, Chamæleon, etc.

4. In what latitude must a person be in to have lost sight of Cassiopeia? *Ans.* South of 60° south latitude.

PROBLEM XLV.

The latitude of a place, the month, day, and hour being given, to place the globe in such position as will represent the heavens at that time.

RULE.—Rectify the globe for the given latitude by Problem XV., and set the globe due north and south by means of the mariner's compass. Find the sun's place in the ecliptic on the terrestrial globe by Problem XIV., and find a declination corresponding with it on the celestial brazen meridian. Turn the celestial globe on its axis until the ecliptic passes under this declination, and set the hour circle to 12 o'clock. If the time be after noon, turn the globe westward, but if before noon, eastward until the index has passed over as many hours as the given time wants of noon. That half of the celestial globe which is above the horizon will represent the heavens at the given time.

PROBLEM XLVI.

To find when any given star will rise, culminate, or set at any given place, the day of the month being given.

RULE.—Rectify the globe for the given latitude by Problem XV., and find the sun's place on the celestial globe as in the preceding problem, and bring it to the graduated side of the celestial brazen meridian. Set the hour circle to 12 o'clock. If the given star be below the horizon, turn the globe westward on its axis until it is brought to it: then will the index on the hour circle show the time from noon when it rises. Continue the motion westward until it is brought under the brazen meridian, when the time of its culmi-

nating will be found by means of the hour circle. Continue the motion still farther westward until the star is again at the horizon. The time of its setting will be found as before by means of the hour circle.

1. At what time at Philadelphia on March 2d will Pollux rise, culminate, and set? *Ans.* It rises at 1 P.M., culminates at 8 hours 45 minutes P.M., and sets at 4 hours 30 minutes A.M., March 3d.

2. At Montreal, when will Mira in Cetus rise, culminate, and set on February 3d? *Ans.* It rises at 11 hours 30 minutes A.M., culminates at 5 hours 15 minutes P.M., and sets at 8 hours 50 minutes P.M.

3. At what time will δ in Aquarius rise, culminate, and set at Gibraltar on August 12th? *Ans.* It rises at 9 P.M., culminates at 1 hour 30 minutes A.M., and sets at 7 A.M.

PROBLEM XLVII.

To find the rising and setting amplitude of a star at any given latitude.

Rule.—Rectify the globe for the given latitude by Problem XV., and bring the given star to the eastern part of the horizon. The number of degrees between the star and the east point of the horizon will be its rising amplitude. Bring the star to the western part of the horizon. The number of degrees between the star and the west point of the horizon will be its setting amplitude.

1. What is the rising and setting amplitude of Aldebaran at Lisbon? *Ans.* Rising amplitude, 21° north of east; setting amplitude, 21° north of west.

2. What is the rising and setting amplitude of Arcturus at Naples? *Ans.* Rising amplitude, 26° north of east; setting amplitude, 26° north of west.

3. What is the rising and setting amplitude of Regulus at Edinburg? *Ans.* Rising amplitude, 22° north of east; setting amplitude, 22° north of west.

PROBLEM XLVIII.

To find the angle that any two stars will subtend as seen by a spectator, or to find their distance from each other in degrees.

RULE.—Lay the quadrant of altitude from one star to the other so that the degree marked 0 may be over one of them. The number of degrees between them on the quadrant will be the angle they will subtend, or their distance in degrees apart.

1. What is the distance in degrees between Nath in Taurus and Algieba in Leo? *Ans.* 68°.

2. What is the distance in degrees between Alwaid in Draco and Schedir in Cassiopeia? *Ans.* 57°.

3. What is the distance in degrees between Alpheratz in Andromeda and Sheratan in Aries? *Ans.* 26°.

PROBLEM XLIX.

Given the latitude of a place, to find the meridian altitude of a star.

RULE.—Rectify the globe for the given latitude by Prob. XV. Bring the star to the celestial brazen meridian. The number of degrees on it between the star and the horizon will be the required meridian altitude.

1. What is the meridian altitude of Arcturus at Detroit? *Ans.* 67°.

2. What is the meridian altitude of Vega in Lyra at Genoa? *Ans.* 82°.

3. What is the meridian altitude of Betelgeux in Orion at Bristol? *Ans.* 44°.

PROBLEM L.

Given the latitude of a place, day of the month, and the altitude of a star, to find the hour of the night, and the star's azimuth.

Rule.—Rectify the globe for the given latitude by Problem XV., and screw the quadrant of altitude to the celestial brazen meridian over the given latitude. Bring the sun's place in the ecliptic for the given day to the graduated side of the celestial brazen meridian, and set the hour circle to 12 o'clock. Turn the celestial globe on its axis westward until the star comes to the given altitude on the quadrant. The number of hours the index has passed over will show the time from noon when the star has the given altitude. The quadrant of altitude will intersect the horizon in the required azimuth.

1. On the 2d of December, the star Deneb in Cygnus was observed at Paris to have an altitude of 27°. What was the hour of observation, and what the azimuth of the star? *Ans.* 10 hours 30 minutes P.M.; azimuth, 52° west of north.

2. At Dublin on July 20th, the star Altair in Aquila was observed to have an altitude of 43°. What was the hour of observation, and what the azimuth? *Ans.* 2 hours 15 minutes A.M.; azimuth, 33° east of south.

3. At Boston on May 8th, the star Antares in Scorpio was observed to have an altitude of 10°. What was the time of observation, and what was the azimuth of the star? *Ans.* 10 hours 30 minutes P.M.; azimuth, 59° east of south.

PROBLEM LI.

The latitude of a place, the day of the month, and the hour of the day being given, to find the altitude of any star, and its azimuth.

RULE.—Rectify the globe for the given latitude by Problem XV., and screw the quadrant of altitude to the celestial brazen meridian over the given latitude. Bring the sun's place in the ecliptic for the given day to the graduated side of the brazen meridian, and set the hour circle to 12 o'clock. If the given hour be before noon, turn the celestial globe on its axis eastward, but if after noon, westward until the index has passed over as many hours as the given time wants of noon. Fasten the globe in this position by screwing the milled screw at the northern extremity of the axis. Move the quadrant of altitude until the star coincides with the graduated side of the quadrant. The degrees on the quadrant from the horizon to the star will be the altitude, and the distance in degrees between the north or south points of the horizon and the graduated side of the quadrant will be the azimuth.

1. What is the altitude and what the azimuth of Bellatrix in Orion on January 7th, at 10 P.M., in Havre? *Ans.* Altitude, 46°; azimuth, 0°.

2. What is the altitude and what the azimuth of Regulus in Leo at 11 P.M. on January 12th at New Orleans? *Ans.* Altitude, 39°; azimuth, 83° east of south.

3. What is the altitude and what the azimuth of Dubhe in Ursa Major at 11 P.M. in Glasgow on April 20th? *Ans.* Altitude, 74°; azimuth, 63° west of north.

PROBLEM LII.

The day of the month and the azimuth of a star at a certain place being given, to find the star's altitude and the hour of the night.

Rule.—Rectify the globe for the latitude of the given place by Problem XV., and screw the quadrant of altitude to the celestial brazen meridian over that latitude. Find the sun's place in the ecliptic, and bring it to the graduated side of the celestial brazen meridian. Set the hour circle to 12 o'clock, and bring the lower end of the quadrant of altitude to coincide with the given azimuth on the horizon. Holding the quadrant in this position, turn the celestial globe on its axis until the given star comes to the graduated edge of the quadrant of altitude. The hours passed over by the index will be the required time from noon. The number of degrees on the quadrant from the horizon to the star will be the required altitude.

1. At London, on September 10th, the azimuth of ε Delphinæ was 20 degrees from the south toward east: what was its altitude, and what the hour of the night?

2. On the 8th of October, at London, the azimuth of β Aurigæ was 50 degrees from the north toward the west: what was the altitude, and what the hour of the night?

3. At New York, on the 17th of March, the azimuth of Regulus was 74° N. of W.: what was the altitude, and what the hour of the night?

PROBLEM LIII.

A given star being on the meridian, and another given star at the eastern or western half of the horizon, to find the latitude of a place.

RULE.—Bring the first given star to the meridian; keep the globe from revolving by screwing the milled head at the northern extremity of the axis; elevate or depress the north pole until the second given star is brought to the eastern or western half of the horizon. The required latitude will correspond in degrees with the altitude of the pole.

1. When Altair was rising and Arcturus in the meridian, what was the latitude? *Ans.* 18° south latitude.

2. What is the latitude of that place which will have Sirius in the meridian while Arcturus is rising? *Ans.* $49\frac{1}{2}°$ north latitude.

3. What is the latitude of that place which will have Aldebaran on the meridian while Nekar in Bootes is rising? *Ans.* 47° north latitude.

PROBLEM LIV.

The latitude of a place, the day of the month, and two stars having the same altitude being given, to find the hour.

RULE.—Rectify the globe for the given latitude by Problem XV., and screw the quadrant of altitude to the celestial brazen meridian over that latitude. Bring the sun's place in the ecliptic for the given day to the graduated side of the brazen meridian, and set the hour circle to 12 o'clock. Turn the globe on its axis

westward until the two given stars coincide with the altitude on the quadrant. The hours passed over by the index will be the time from noon to the required hour.

1. At what hour at London will Menkar in the Whale's jaw and Aldebaran, on the 5th of January, have each 35° of altitude?

2. At what hour at Edinburg will Altair in the Eagle and ζ in the tail of the Eagle have, on the 18th of November, each an altitude of 35°?

3. At what hour at Dublin, on May 15th, will Benetnach in Ursa Major and γ in Bootes have each 56° of altitude?

PROBLEM LV.

Two stars having the same azimuth, and their respective altitudes being given, to find the latitude.

RULE.—Extend the graduated edge of the quadrant of altitude from one star to the other, so that each star may stand opposite its given altitude on the quadrant. Elevate or depress the north pole until that division of the quadrant marked 0 is at the horizon: then will the required latitude correspond in degrees with the altitude of the pole.

1. The altitude of Arcturus was observed to be 40°, that of Cor. Caroli 68°, and their common azimuth 71° from south toward east: what was the latitude? *Ans.* $51\frac{1}{2}°$ north.

2. The common azimuth of Vega in Lyra and α in Hercules was 60°, and their respective altitudes 70° and $39\frac{1}{2}°$: what was the latitude?

3. The respective altitudes of α and γ in Ursa Major were 40° and $29\frac{1}{2}°$, and their common azimuth 30°: required the latitude.

PROBLEM LVI.

The day of the month, and the hour when any known star rises or sets being given, to find the latitude of the place.

RULE.—Bring the sun's place on the ecliptic for the given day to the graduated edge of the celestial brazen meridian, and set the hour circle to 12 o'clock. If the given time be before noon, turn the globe eastward, but if after noon, westward on its axis as many hours as the given time wants of noon. Elevate or depress the north pole of the globe until the given star is brought to the horizon. The required latitude will correspond in degrees with the altitude of the pole. If the south pole be elevated, the latitude will be south, but if the north pole, it will be north.

1. In what latitude does Mirach in Bootes rise at half past twelve at night on December 10th? *Ans.* $51\frac{1}{2}^\circ$ north.

2. In what latitude does Pollux rise at 9 P.M. on September 12th?

3. In what latitude does Sirius rise at 2 A.M. on January 14th?

PROBLEM LVII.

To find that day of the year on which any given star passes the meridian at any given hour.

RULE.—Bring the given star to the graduated edge of the meridian, and set the hour circle to twelve o'clock. If the given hour be before noon, turn the globe westward, but if after noon, eastward until the index has passed over as many hours as the given

hour wants of noon. The required day will be found on the ecliptic where it is crossed by the brazen meridian.

1. On what day of the year does Procyon come to the meridian of London at 3 A.M.? *Ans.* December 1st.

2. On what day of the month does Deneb in Leo come to the meridian of Washington at 9 P.M.?

3. On what day of the year does Bellatrix come to the meridian of New York at 11 P.M.?

PROBLEM LVIII.

The day of the month being given, to find at what hour a given star will come to the meridian.

RULE.—Bring the sun's place on the ecliptic for the given day to the graduated side of the brazen meridian, and set the hour circle to twelve o'clock. Turn the globe on its axis westward until the given star comes to the graduated side of the meridian. The hours passed over by the index will be the hour from noon when the given star comes to the meridian.

1. At what hour does Regulus in Leo come to the meridian of London on September 23d? *Ans.* 9h. 45m. A.M.

2. At what hour will Menkar come to the meridian of New York on May 1st?

3. At what hour will Dubhe come to the meridian of New York on March 30th?

PROBLEM LIX.

The altitudes of two stars being given, to find the latitude of a place.

RULE.—Subtract the latitude of each star from 90°, and with the remainders in degrees equal to those on the equinoctial, with the given stars as centres, describe two arcs intersecting each other in the zenith. Bring this point of intersection to the graduated edge of the meridian, and that number on the meridian which coincides with the point of intersection will be the required latitude.

Note.—To describe arcs on a glass globe, it is necessary to use a pencil made of hard soap.

1. At sea, in north latitude, the altitude of Capella was observed to be 30°, and that of Aldebaran 35°. What was the latitude? *Ans.* 20½° north.

2. When the altitude of Markab in Pegasus was 30°, that of Altair in Aquila was 65°. What was the latitude in the northern hemisphere?

3. When the altitude of Procyon was observed to be 50°, that of Betelgeux in Orion was 58°. What was the latitude of the place of observation?

PROBLEM LX.

Given the meridian altitude of any particular star, to find the latitude.

RULE.—Find the declination of the given star, and bring a corresponding declination on the other side of the equinoctial to the horizon. The elevation of the pole will correspond with the required latitude in degrees. If the north pole be elevated, the latitude will

be north, but if the south pole, the latitude will be south.

1. In what degree of north latitude is the meridian altitude of Aldebaran $52\frac{1}{2}°$? *Ans.* $53\frac{1}{2}°$.

2. In what degree of north latitude is the meridian altitude of Altair 90°?

3. In what degree of north latitude is Regulus in the zenith when he culminates?

PROBLEM LXI.

Given the latitude of a place, the day and hour, together with the altitude and azimuth of a star, to find the star.

Rule.—Rectify the globe for the latitude by Problem XV., and screw the quadrant of altitude to the celestial brazen meridian over the given latitude. Find the sun's place in the ecliptic for the given day, and bring it to the graduated side of the brazen meridian. Set the hour circle to twelve o'clock. If the given hour be before noon, turn the globe on its axis eastward, but if after noon, westward until the index has passed over as many hours as equals the difference between the given hour and noon. Secure the globe in this position by screwing the milled head at the northern extremity of the axle, and bring the division marked 0 on the quadrant to the given azimuth on the horizon. Then under the given altitude on the quadrant will be found the required star.

1. At London, on December 21st, at 4 o'clock in the morning, the altitude of a star was 50°, and its azimuth 37° from the south toward the east. What was the name of the star? *Ans.* Deneb in Leo.

2. At London, on December 21st, at 4 o'clock A.M.,

the altitude of a star was 8°, and its azimuth 51° from the south toward the west. What was the name of the star?

3. At London, on September 1st, at 9 P.M., the altitude of a star was 47°, and its azimuth 73° from the south toward the east. What was the name of the star?

THE END.

LIBRARY OF CONGRESS
0 003 538 866 7